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UTILIZATION OF BUTTERMILK IN THE FORM OF CONDENSED AND DRIED BUTTERMILK[1]

O. F. HUNZIKER

Blue Valley Creamery Company, Chicago, Illinois

Received for publication October 23, 1922

ANNUAL VOLUME OF BUTTERMILK PRODUCED IN UNITED STATES

According to figures compiled by the United States Department of Agriculture the total output of American Creamery butter in 1921 was 1,054,938,329 pounds.

Assuming that with each pound of butter manufactured there is produced 1.5 pounds of buttermilk, the total production of factory buttermilk would amount to about 1,562,407,494 pounds.

USES OF BUTTERMILK

Aside from its use for feeding purposes, buttermilk has been found valuable and useful as the basis for diverse manufacturing purposes. It is used in bakeries and in the manufacture of prepared foods, for cottage cheese and milk beverages, casein products, lactic acid and similar industrial products.

The volume of buttermilk used for these miscellaneous purposes, however, represents but a very small portion of the total annual supply of buttermilk, and it is fair to admit that at this stage of the industry those sundry purposes are as yet a negligible factor in the solution of the economic utilization of the buttermilk supply.

The basic value of buttermilk lies in the high quality of its solid ingredients for feeding purposes, and it is through the channel of feeding the buttermilk to farm animals and fowl, and to a limited extent to the human family, that the more complete and economic utilization of the vast bulk of our annual output of buttermilk must find its ultimate solution.

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[1] Delivered before the Manufactures Section of the American Dairy Science Association, October 10, 1922, St. Paul, Minnesota.

On the basis of 30 cents per hundred pounds, which is a very conservative estimate when compared with present prices of grain (corn now ranges between 60 and 65 cents per bushel) the value of the annual output of 1,582,000,000 pounds of buttermilk represents a value to the farmer of the country of approximately $4,750,000.

If disposed of by the butter manufacturer at the conservative price of 1 cent per gallon or 12 cents per 100 pounds, it would net the creameries of the country annually around two million dollars.

A considerable volume of buttermilk is returned direct to the farmer for hog and poultry feeding. This direct outlet is confined largely to local creameries where the cow population is dense and the distance from farm to factory is relatively short. And even in this case, the demand for the buttermilk is very irregular and the facilities for its proper disposition through this channel are entirely inadequate to the supply.

In the larger creameries, that receive their cream supply from a much wider radius, the distance of the average patron from the creamery limits the amount of buttermilk that can be returned direct to the farmer to a very small volume. This is especially true in the case of the creameries located in large cities.

Prior to the World War the great bulk of the buttermilk supply was a complete loss. It was run into the sewer, although some efforts had been made for several years to convert the buttermilk into a more concentrated form and into a form that would render it less perishable and that enhanced its keeping quality.

DEVELOPMENT OF MANUFACTURE OF CONDENSED AND DRIED BUTTERMILK

The manufacture of condensed buttermilk and of dried buttermilk prior to the World War was exceedingly limited. In fact, it did not really go beyond the experimental state, only a very limited amount of either product reaching the market. The relatively low price of grain feeds and of pork, poultry and eggs did not seem to justify the addition to the price of fluid buttermilk of the comparatively high cost of manufacture into the more concentrated products. Also the process of condensing and drying buttermilk had not as yet reached the point where products of dependable keeping quality were entirely assured.

Practically the only kind of so-called condensed buttermilk then made at all, was not really the result of concentration proper. It was a product made by heating the buttermilk in large tanks to the boiling temperature long enough for the curd to contract and to settle to the botton, leaving a practically clear whey on top. This whey was drawn off and thrown away. The residue, consisting of the curdy material and as much of the whey as adhered to or remained mixed with it constituted the condensed buttermilk. It is obvious that this product was not a complete buttermilk, much of the lactose, lactic acid and mineral salts having been lost. Only a small quantity of this product ever reached the market.

Small quantities of dried buttermilk were also made and used largely in mixed feeds for poultry.

The feed shortage and the high prices of all farm products caused by the ravages of the World War greatly emphasized the possibilities and the value of preserving such by-products as buttermilk. With prices of farm products doubling and in some instances trebling, and the demand for these products reaching far beyond their supply, the cost of concentrating and of drying buttermilk was no longer a serious obstacle. The farmer and the feeder could afford to pay the price and the manufacture of these concentrated products became a profitable industry.

The processes of manufacture were perfected rapidly and the volume of these finished products, condensed buttermilk and dried buttermilk, increased by leaps and bounds.

Like in other similar industries the attractiveness of the possible profits during the years of forced prosperity created by the war, so in the manufacture of condensed and dried buttermilk it led to overproduction, I mean production greater than the demand, in normal times. With the general business depression and reaction that set in a few years ago, and the resulting decrease in the demand and depreciation of the value of farm products, these industries too suffered and will continue to suffer to some extent until the period of reconstruction will have reached a point of reasonable stability and comparative normalcy.

However, the efforts put into these industries have by no means been in vain. They have developed definite processes of manufacture of condensed buttermilk and of dried buttermilk. These products have been tried out and found useful and their value as stock feeds has been definitely established and is recognized.

Reports from those close to the industry point to the fact that the volume of production for 1922 is far in advance of 1921 and that there is a rapidly increasing demand on the part of the feeder for these products. Much educational work has been done during the last two years in acquainting the feeder with the value and proper use of these products. This has helped and will continue to assist in accelerating their use and their demand.

The total output of condensed buttermilk in 1921 was 29,313,767 pounds. This represents approximately 87,941,301 pounds of fluid buttermilk or 5.6 per cent of the total annual amount of fluid buttermilk produced. The total output of dried buttermilk for the same year was 7,708,384 pounds. This represents approximately 77,084,000 pounds of fluid buttermilk or 4.9 per cent of the total annual output of the fluid buttermilk. With other words, about 10.5 per cent of the 1,582,407,494 pounds of fluid buttermilk produced in 1921 was utilized for the manufacture of condensed buttermilk and dried buttermilk.

Practically the entire make of 29,313,767 pounds of condensed buttermilk was sold for feeding purposes. Only negligible amounts went to bakeries. Of the total of 7,708,384 pounds of dried buttermilk approximately 200,000 pounds went for human consumption. The remainder was used for feeding purposes.

The great bulk of condensed buttermilk is manufactured by evaporation in the vacuum pan similar as in the case of the manufacture of condensed milk. The process of concentrating buttermilk in vacuo is covered by patent of the Grelck-Hovey Patent Company of St. Paul, Minn.

In the manufacture of dried buttermilk, both the spray process and the roller process have been employed. In the spray process as used in the central west, the buttermilk is first condensed in the vacuum pan and the condensed buttermilk is then atomized and dried in a current of hot air. This process is covered by the Merrill-Soule Company patent. The amount of buttermilk powder so manufactured is very small.

Practically 90 per cent of the entire output of dried buttermilk for the year 1921 was made by the roller process covered by patent of the Collis Products Company of Clinton, Iowa. In this process the buttermilk is kept in a thoroughly agitated condition and is sprayed on a steam heated revolving roller which makes about two revolutions per minute and the temperature of the product reaches about 190 to 200°F. The thin film of drying buttermilk that forms on the roller is automatically removed by a stationary sharp knife. This thin film is still slightly moist when it comes off the roller, but it surrenders the remainder of its removable moisture quickly to the atmosphere. Instead of spraying the uncondensed fluid buttermilk on the roll, the buttermilk may be precondensed and then sprayed on the roll.

Some dried buttermilk is also manufactured by the roller process of the Just-Hatmaker type of machine (two rollers) and by the roller process in vacuum, which was originally invented by Dr. Ekenberg of Stockholm, Sweden, and the machinery of which is now manufactured and patented by the Buffalo Foundry and Machine Company, Buffalo, N. Y.

COMPOSITION

Neither condensed nor dried buttermilk contain any ingredients not present in the original buttermilk, nor is any ingredient present in the original buttermilk decreased or removed except the water. The two products differ from each other only in their degree of concentration. The proportion of the individual solid ingredients to one another in each product is practically the same and it is the same also as it is in the fluid buttermilk with the exception of the percentage of lactic acid which is relatively much higher and the percentage of milk sugar which is correspondingly lower in the condensed buttermilk than in the dried buttermilk and than in average fluid buttermilk.

The ratio of concentration of condensed buttermilk averages about three to one, but there is a very considerable variation in different lots of condensed buttermilk that reach the market. Since fluid buttermilk averages about 9 per cent total solids and 91 per cent water, the condensed buttermilk averages from about 25 to 33 per cent total solids and from about 67 to 75 per cent water.

In dried buttermilk the ratio of concentration is slightly over 10 to 1. It is more even in its composition. It contains from about 90 to 95 per cent milk solids and from about 5 to 10 per cent water.

KEEPING QUALITY

Condensed buttermilk is a far more perishable product than dried buttermilk. In order to lend it proper keeping quality, the buttermilk before condensing must be soured to a point sufficient to produce a condensed buttermilk with not less than 3 to 3.5 per cent acid, calculated as lactic acid. If the acid content of the condensed buttermilk drops below the above figure, the product deteriorates very rapidly, usually becoming moldy and putrid. Also the contents of remnant barrels of condensed buttermilk mold very profusely unless the surface of the condensed buttermilk is protected from the air, as can be readily done by covering it with heavy paper, or similar material.

Dried buttermilk has very good keeping quality. Its high acid content, which is around 5 per cent, due to its high ratio of concentration, and its relatively low moisture content, act as effective preservatives. It keeps best, however, when protected against air and heat.

FOOD VALUE AND MARKET PRICE

From the standpoint of the percentage ingredients as determined by chemical analysis, the relative food value of condensed buttermilk and of dried buttermilk is controlled entirely by the ratio of concentration or the percentage of total solids. On this basis, the dried buttermilk has at least three times the food value of condensed buttermilk and condensed buttermilk has about three times the food value of fluid buttermilk. The market price of condensed buttermilk for feeding purposes is about 5 cents per pound. The market price of dried buttermilk for feeding purposes is about 8 cents per pound. Feeders who buy these concentrated products direct from the manufacturer may secure them at a reduction of from ½ to 1½ cents or slightly over. The above prices are jobbers' prices to the feeder.

Based on the percentage of total solids in the two products, therefore, it would appear that the feeder of dried buttermilk receives considerably more milk solids and therefore greater food value for every dollar expended than the feeder of condensed buttermilk. Also there is much less danger of loss by spoiling, there is less storage room required and the cost of transportation is less than in the case of condensed buttermilk. Comparing dried buttermilk with an average per cent of solids of 92½ per cent and a cost to the feeder of 8 cents per pound, and condensed buttermilk with an average per cent of solids of 27 per cent and a cost of 4 cents per pound with the value of fluid buttermilk testing 9 per cent solids, the feeder when buying dried buttermilk is paying at the rate of 78 cents per hundred pounds or 6.3 cents per gallon of fluid buttermilk. In case of condensed buttermilk he is paying at the rate of $1.33 per hundred pounds, or of 11 cents per gallon of fluid buttermilk.

When sold direct by manufacturer to the feeder the price to the feeder is considerably less. Dried buttermilk sells at 6½ cents and condensed buttermilk sells at 3½ cents per pound. At these prices the feeder, when buying dried buttermilk, would be paying at the rate of 65⅔ cents per hundred or 5½ cents per gallon of fluid buttermilk. When buying condensed buttermilk he would be paying at the rate of $1.16 per hundred or 9½ cents per gallon of fluid buttermilk.

It is further claimed that in the case of condensed buttermilk, the real value of the product as a feed is materially augmented by its very high content of acid, calculated as lactic acid. Condensed buttermilk contains about 3.5 per cent acid.

That lactic acid in the diet has a value as a tonic is generally admitted by nutrition and health experts. Its value lies in cleansing the intestines from putrefaction and keeping them in a healthy condition; in accelerating the power of assimilation of other feeds in the ration, thereby augmenting their digestibility and their economy as feeds; and in giving the animal greater capacity for the consumption of feed and water.

To what extent this tonic effect of condensed buttermilk does increase the value of this product, is as yet undetermined. It is reasonable to assume that the effect is advantageous but the information available is as yet too limited to interpret this value in terms of dollars and cents.

VITAMINE PROPERTIES

There are no experimental data on record, or at least I have been unable to find any, on the relative vitamine properties of condensed and dried buttermilk, nor even of liquid buttermilk. However, the effect of condensing and dehydrating of milk has been subjected to considerable study and it may be justifiable to use these data as an approximate criterion of the vitamine properties in the buttermilk products.

Ellis and Macleod (1), Sherman and Smith (2), Funk (3), and Eddy (4), in their respective reviews of experimental results with condensed milk and dried milk when fed to rats, other animals and to children, point out that neither the fat soluble A nor the water soluble B vitamines were noticeably affected by the processes of evaporation and drying.

Vitamine C, the antiscorbutic vitamine, on the other hand, suffered variably according to the process used. Condensing in vacuo and drying by the roller process had the least unfavorable effect. The spray drying process at high temperatures in the drying chamber and exposure of the milk powder for several hours on the floor of the drying chamber practically destroyed vitamine C.

These data suggest quite clearly that neither the condensing of buttermilk in the vacuum pan, nor the drying of the buttermilk by the roller process, both processes whereby the great bulk of condensed buttermilk and dried buttermilk respectively, are manufactured, have any appreciable effect on the vitamine properties of the finished product.

The fact that the fat soluble A and the water soluble B vitamines are preserved during the processes of heating, condensing and dehydrating is important because the grain feeds are deficient in these vitamines and the buttermilk products thus are a valuable supplement to these feeds. The possible depreciation or destruction of vitamine C in the buttermilk products is of negligible importance as the grain feeds amply supply this vitamine.

However, it should be understood that the results above referred were obtained with milk products and not with buttermilk products. It is possible, though not probable, that the same processes that are harmless or negative as far as their effect on the vitamine properties of sweet milk is concerned, may have a different influence in the case of highly acid buttermilk.

DIGESTIBILITY

Accurate data on the relative digestibility of dried and condensed buttermilk as compared with fluid buttermilk are likewise lacking. Dr. Miner (5) of the Miner Laboratories, Chicago, reports a limited number of digestibility tests made in the laboratory. These tests indicated that the digestibility of the condensed and dried buttermilk was equal to that of the fluid buttermilk. These results correspond with those of digestibility tests with condensed and dried milk reported by numerous investigators. However, the digestibility tests on the condensed and dried buttermilk were restricted to laboratory tests only and limited in number. They therefore should be accepted as an indication rather than as a proven fact.

FEEDING EXPERIMENTS

Results of carefully executed feeding experiments that show the comparative food value and economy are as yet too limited to arrive at definite conclusions and in many cases the experiments were made with products especially furnished for the purpose by the manufacturer. While experiments conducted under such circumstances are of unquestionable value, the results obtained therefrom, should be amply verified by experiments on a broader scale with products as they appear in the trade, before they can be accepted as scientifically established and unbiased facts.

Evvard and Dunn (6) of the Iowa Experiment Station report experimental results with dried buttermilk for pigs. Dried buttermilk was added to the basal ration of corn, tankage and salt. The dried buttermilk increased the gains on pigs and decreased the feed requirements for a 100-pound gain. The buttermilk proteins proved more efficient than the tankage proteins, but the buttermilk proteins cost more than the tankage proteins. From the standpoint of economy, tankage at $100 per ton for market pig feeding proved much more efficient than buttermilk powder at $200 per ton, the relative prices at the time of the experiment. On the basis of the above prices and the relative feeding results these investigators place the value of buttermilk powder at $4 per hundred weight.

Mr. H. I. Macomber (7) of the Poultry Division of the United States Department of Agriculture reported experiments with laying hens. Fifteen per cent of dried buttermilk was fed in a poultry mash as compared with 25 per cent meat scrap of a 55 per cent protein analysis. The hens were laying as well on the buttermilk as on the meat scrap. Condensed buttermilk was also used, for its tonic value, but not to replace all of the animal protein feed. While the experiment is not as yet completed and it is too early for accurate figures as to cost, indications are that 15 per cent dried buttermilk in the mash will cost as much as 25 per cent of the meat scrap with present prices. Their observations are that the dried buttermilk is a much easier form of feed to handle than the condensed buttermilk and that the dried buttermilk apparently was as satisfactory as a feed. Macomber further reports that both of these feeds have also been used in poultry fattening tests with the same comparative results as noted in the feeding of laying hens. He concludes that in his opinion more experimenting is required to arrive definitely at conclusions regarding the relative merits of dried and condensed buttermilk.

Philips (8) in Purdue Bulletin 258 reports results of feeding experiments with fluid and dried buttermilk with laying hens. Pullets in the dried buttermilk pen laid on an average of 189.4 eggs, in the fluid buttermilk pen 164.7 eggs, in the no buttermilk pen 56.6 eggs. It cost 16 cents for feed to produce one dozen eggs in both the dried and the fluid buttermilk pens, and 33 cents in the no buttermilk pen.

The profit over feed from the dried buttermilk pen was $5.69, from the fluid buttermilk it was $4.92, and from the no milk pen it was $0.78. The feeding value of dried buttermilk was $55.10 per 100 pounds, and of the fluid buttermilk it was $5 per 100 pounds.

The dried buttermilk produced the best fertility of eggs and the fluid buttermilk the poorest. The mortality in the dried buttermilk pen and the fluid buttermilk pen was the same. That in the no milk pen was much heavier.

Similar results are also reported in experiments with chickens conducted at the Iowa Experiment Station, but the experiments are not as yet entirely complete.

SUMMARY

The utilization of the great bulk of the vast volume of creamery buttermilk annually produced in the form of condensed buttermilk and dried buttermilk gives promise to be of distinct economic value both to the feeder of farm animals and as a means to minimize waste of a valuable marketable by-product to the creamery.

While considerable quantities of these concentrated by-products are now being manufactured and marketed to the advantage of feeder and manufacturer, this industry is as yet in its infancy.

This, together with the fact that supplies such as coal and package, also labor and transportation, are as yet abnormally high, has been a handicap that has worked against the full realization of the possibilities of maximum efficiency and of minimum cost of manufacture.

Knowledge of the comparative feeding value of these two products is as yet limited but much and extensive experimental work is in progress, the result of which promises to reveal facts of great economic value to feeder and manufacturer. Information now available indicates that the food value, digestibility and vitamine properties originally contained in the fluid buttermilk are not materially affected by the processes of condensation and drying now used in the manufacture of these products.

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CLASS LEADERS IN AGRICULTURAL COLLEGE HERDS

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Probably every agricultural college in the United States has a herd of dairy cattle. It would not seem to be possible to successfully carry on the dairy work at the institution without some dairy animals. Since there are four principal breeds of dairy cattle that have any general distribution throughout the country, the ideal condition would be to have each represented at the several institutions. A herd of dairy cattle at the state agricultural college serves a number of purposes: (1) Furnishes animals for instructional work in dairy cattle judging; (2) Furnishes animals for experimental work; (3) Furnishes milk for use in instructional work; (4) Furnishes milk for experimental work; (5) Serves as an ideal toward which the breeders of the state may strive. Very likely many college herds do not, to the fullest extent, serve all the functions mentioned. Especially is the last mentioned difficult to perform. Many, if not most, of the colleges have been greatly hampered from lack of funds for the purchase of foundation females or the proper kind of sires to successfully carry on breeding operations. At various times during the last few years, it has been the privilege of the senior author to visit many of the agricultural colleges and the records then prevailing and those presented here show a remarkable improvement in the productive ability of their dairy cows. It is considered doubtful if the breeders of dairy cattle generally, appreciate how good the college herds are at present and it was also thought likely that those connected with the various institutions would like to know how their herds compared with those of other places. With this in mind a questionnaire was sent out to thirty-five institutions asking for the leading official record cow in each of the age classes for the four breeds, Holstein, Jersey, Guernsey and Ayrshire. Replies containing information were received from twenty four institutions. Only cows actually in the herd were to be included and only those having official records. The average production figures were not received from enough institutions to warrant their presentation. In general the records given represent March 1, 1922. Unquestionably, a number of excellent records have been made since that date which would change the leaders.

HOLSTEINS

Of the twenty-four institutions replying, twenty-three reported owning Holsteins, the University of Maryland alone owning none. The highest butterfat record reported for the aged cow class (cows five years old or over) was made by La Verna Lincoln owned by the University of Nebraska whose record is 29,555.5 pounds of milk and 1048.4 pounds of butterfat. She is also the highest producing cow in butterfat owned by any of the agricultural colleges, and it is believed that she is the highest milk producer. In this class three institutions report cows producing over 900 pounds of butterfat; six report cows producing over 800 pounds of butterfat; ten report cows producing over 700 pounds of butterfat; fifteen report cows producing more than 600 pounds of butterfat and nineteen report cows producing more than 500 pounds of butterfat. The average production for the twenty-two cows reported in the mature Holstein class is 20,382.5 pounds of milk and 695.7 pounds of butterfat. It must be remembered that the questionnaire asked only for the highest producing cow in a particular class. Undoubtedly, many institutions own several cows that are above the leading animals from other institutions.

The senior four year olds are led by Juna Longfield Homestead owned by the University of Illinois with a production record of 24,655.5 pounds of milk and 828.5 pounds butterfat. In this class there are two cows with records of over 700 pounds of butterfat, six cows over 600 pounds butterfat and 14 cows having produced more than 500 pounds butterfat. The average production for the nineteen cows in this class is 17,221.2 pounds of milk and 568.5 pounds butterfat.

The junior four year old class is led by Virginia Polytechnic Institute with the cow V. P. I. Veeman De Kol whose production is 17,333.0 pounds of milk and 764.0 pounds butterfat. This class has two cows above 700 pounds of fat, six cows above 600 pounds of fat and fifteen cows having produced more than 500 pounds of butterfat. The average production for the nineteen cows in this class is 16,244.5 pounds milk and 557.7 pounds of butterfat.

California Agnes Colanthaa owned by the University of California leads the senior three year old class with a production of 19,409.6 pounds of milk and 689.9 pounds of butterfat. This class has four cows producing more than 600 pounds of butterfat and eight cows producing more than 500 pounds of butterfat. The average milk production for the eighteen cows reported in this class is 15,271.8 pounds milk with 514.0 pounds of butterfat.

Illini Dulcina De Kol owned by the University of Illinois tops the junior three year old class with a production of 17,755.4 pounds of milk and 719.7 pounds of butterfat. In this class there are six cows above 600 pounds of fat and eleven cows above 500 pounds of fat. The seventeen cows reported in this class have an average production of 15,426.2 pounds milk and 529.9 pounds of butterfat.

California Pietertje Bloom Mead owned by the University of California leads the senior two year old class with a production of 19,985 pounds of milk and 722.2 pounds of butterfat. Two cows in this class produced more than 700 pounds of butterfat, three cows more than 600 pounds of butterfat and nine cows more than 500 pounds butterfat. The nineteen cows in this class have an average of 15,172.7 pounds of milk and 514.17 pounds of butterfat.

Junior two year olds are led by Fairy Aaggie Korndyke Colantha owned by the University of Minnesota whose production is 20,005.5 pounds of milk and 696.8 pounds butterfat. Two cows in this class have records of more than 600 pounds of fat and five cows have records of more than 500 pounds of fat. The average for the twenty-two cows in this class is 13,111.8 pounds of milk and 447.21 pounds of butterfat. The average of all the 136 Holstein cows is 16,162.8 pounds of milk and 547.73 pounds of butterfat.

JERSEYS

As in Holsteins twenty-three institutions reported Jerseys. Among the Jerseys, Majesty's Iris owned by the University of Illinois leads the mature cow class and all Jersey classes with a production of 17,469.7 pounds of milk and 955.8 pounds butterfat. Two Jerseys in the mature class have produced more than 900 pounds of butterfat; three have produced more than 800 pounds of fat; five have produced more than 700 pounds of fat; fourteen have produced more than 600 pounds of fat and sixteen have produced more than 500 pounds of butterfat. The eighteen cows in this class have an average production of 12,259.8 pounds of milk and 673.3 pounds butterfat.

Senior four year old Jerseys are led by Lass Princess owned by the Massachusettss Agricultural College who produced 10,808.0 pounds of milk and 701.1 pounds butterfat. This class has seven cows that have produced more than 600 pounds of butterfat and eleven cows that have produced more than 500 pounds of butterfat. The fifteen members of this class have an average production of 9,999.1 pounds milk and 542.2 pounds of butterfat.

Interested Jap's Santa owned by the University of California leads the junior four year olds with a production of 13,308.5 pounds of milk and 805.72 pounds of butterfat. Three cows in this class have produced more than 600 pounds of butterfat and seven cows have produced over 500 pounds of butterfat. The eleven cows reported in this class have an average production of 9,950.0 pounds of milk and 535.77 pounds fat.

Oregon Maple G owned by the Oregon Agricultural College leads the senior three year olds, having produced 10,776.0 pounds milk and 650.2 pounds butterfat. Three cows in this group have produced more than 600 pounds of butterfat and ten cows have produced more than 500 pounds of butterfat. Fifteen cows were reported in this class and the average production is 9,472.3 pounds of milk and 521.66 pounds butterfat.

Trill Pogis of Lily Dale owned by the University of Minnesota leads the junior three year old class with a production of 12,159.0 pounts of milk and 682.0 pounds butterfat. Two cows in this group have produced more than 600 pounds of butterfat and two cows have produced more than 500 pounds of butterfat. The average production of the sixteen cows in this class is 8,413.2 pounds of milk and 444.5 pounds of butterfat.

Interested Jap's Santa owned by the University of California is again the leading cow in the senior two year old class with a production of 9,051.0 pounds of milk and 588.2 pounds butterfat. Three cows in this group have produced more than 500 pounds butterfat. The average production of the fifteen cows reported in this class is 7,736.8 pounds of milk and 413.2 pounds butterfat.

Pennsylvania State College leads the junior two year olds with Penstate's Torono's Blacky who produced 9,854.7 pounds milk and 532.3 pounds butterfat. Two cows in this class have records of more than 500 pounds butterfat. The nineteen cows in this class have an average production of 7,865.5 pounds milk and 419.6 pounds butterfat. Altogether the 109 Jerseys averaged 9,378.8 pounds milk and 520.3 pounds butterfat.

GUERNSEYS

Twenty institutions reported Guernseys, but there were more classes unfilled which seems to indicate that the Guernsey herds are smaller. Yeksarose 4th, owned by the University of Illinois leads the Guernseys in the mature class and in all classes in butterfat production, her record being 14,527.1 pounds milk and 753.7 pounds fat. Seven cows in this group have a production of over 600 pounds butterfat and ten cows have more than 500 pounds butterfat. The twelve cows in this class have an average production of 12,749.9 pounds milk and 619.7 pounds butterfat.

College King's Nantaska owned by the Massachusetts Agricultural College leads the senior four year old class with 14,811 pounds milk and 684 pounds of butterfat. Two cows in this group have produced more than 600 pounds butterfat and an equal number have produced more than 500 pounds butterfat. Only nine cows were reported in this class and they have an average production of 9,581.5 pounds milk and 453.2 pounds butterfat.

Delza 3rd, owned by Pennsylvania State College takes front rank in junior four year olds with a production of 10,608.7 pounds milk and 542.5 pounds fat. Two cows produced over 500 pounds fat and the average of the 8 cows was 9,045.5 pounds milk and 443 pounds fat.

Nantaska Beauty owned by the Massachusetts Agricultural College with a production of 11,359 pounds of milk and 608 pounds of butterfat ranks first among the senior three year olds. Two cows in this group have records of more than 600 pounds butterfat and four cows have records of more than 500 pounds butterfat. The average production of the eight cows in this class is 9,803.3 pounds of milk and 489.2 pounds butterfat.

Squire des Blicqs's Ramona of Beatrice owned by the University of Nebraska leads the junior three year old class having produced 10,672 pounds of milk and 501 pounds of butterfat. The average production of the nine cows reported in this class is 8,223.1 pounds milk and 416 pounds butterfat.

Imp. Rouge II of the Brickfield owned by the Iowa State College is the leading cow among the senior two year olds. Her production being 10,963 pounds milk and 612.5 pounds butterfat. Two cows in this class have produced more than 500 pounds of butterfat. The average for the ten members in this class is 8,219.1 pounds milk and 418.9 pounds butterfat.

May King's Alvada owned by Clemson Agricultural College (S.C.) leads the junior two year olds with a production of 12,294.9 pounds milk and 538 pounds butterfat. Four cows in this group have produced more than 500 pounds butterfat. The fifteen cows in this class have an average production of 8,200.3 pounds milk and 417.1 pounds butterfat. Considering all classes seventy-one Guernseys averaged 9,425.7 pounds of milk and 467.1 pounds of butterfat.

AYRSHIRES

Eighteen institutions reported Ayrshires and in this breed also the indications point to small herds. Canary Bell owned by the Kansas State Agricultural College leads the mature Ayrshires and all Ayrshires in both milk and butterfat production. Her record being 19,863 pounds milk and 744.51 pounds of butterfat. Two Ayrshires in this class have produced more than 700 pounds of butterfat; four more than 600 pounds butterfat and eight have produced more than 500 pounds of butterfat. The average of the fourteen entries in this class is 12,631.1 pounds milk and 537.5 pounds butterfat.

Bangora's Fizzaway owned by Purdue University, Indiana, leads the senior four year olds with a production of 14,983 pounds milk and 532 pounds butterfat. Three cows in this group have produced more than 500 pounds butterfat. Only seven entries were reported in this class with an average production of 12,389.5 pounds of milk and 478.6 pounds butterfat.

Victor's Beauty Lass, a junior four year old owned by the Massachusetts Agricultural College leads her class with a production of 15,980 pounds of milk and 666 pounds butterfat. Two cows in this class have produced more than 500 pounds butterfat. The ten members of this class have an average production of 11,220.3 pounds milk and 450.4 pounds butterfat.

Bangora's Melrose owned by the Kansas State Agricultural College is the leader of the senior three's with a production of 14,515 pounds milk and 568.1 pounds butterfat. Two cows in this group have produced more than 500 pounds butterfat. Only six entries are reported in this class with an average production of 10,997.8 pounds milk and 474.4 pounds butterfat.

Cavaliers Robin Hood Lass of the Iowa State College is leading the junior three year old class, her production being 9,830 pounds of milk and 472.4 pounds butterfat.

Juno of Rossbourg owned by the University of Maryland leads the senior two year old's with a production of 12,371 pounds of milk and 537 pounds of butterfat. Three cows in this group have produced more than 500 pounds of butterfat. The average production of the nine cows reported in this group is 10,346.3 pounds of milk and 434.7 pounds butterfat.

Melrose Canary Bell owned by the Kansas State Agricultural College leads the junior two year old class with a production of 13,785 pounds of milk and 502.9 pounds of butterfat. She is the only cow in this class which has a production of more than 500 pounds butterfat. The average production for the eleven entries in this class is 9,086.1 pounds milk and 378.6 pounds butterfat.

In Ayrshires sixty-eight cows in all classes averaged 10,787.4 pounds milk, 446.8 pounds of butterfat.

Holsteins

RANK	OWNER	COW	MILK	FAT
		Mature Holsteins		
			pounds	*pounds*
1	University of Nebraska	La Verna Lincoln	29,555.5	1,048.4
2	Virginia Polytechnic Institute	Buckeye De Kol Pauline 2nd	20,784.0	927.0
3	University of Illinois	Illini Homestead Beachwood	25,535.1	901.6
4	Connecticut Agricultural College	De Kol Hubbard Pietertje	23,175.7	830.7
5	University of Idaho	Idaho Violet Posch Ormsby	21,379.3	805.9
6	Kansas State Agricultural College	Carlotta Empress Fobes	27,398.0	803.3
7	University of Minnesota	Lady Oak Fobes De Kol	22,063.0	794.0
8	University of California	California Agnes Colantha	21,801.4	788.4
9	Massachusetts Agricultural College	Concordia Pietertje	24,200.0	782.0
10	Iowa State College	Genoesca Belle Polkadot	20,816.2	732.9
11	New Jersey Agricultural College	College King Beauty	19,643.5	699.4
12	Purdue University	Segis Colantha Bakker	22,432.0	693.0
13	Pennsylvania State College	Lilith Gem Kolkluff	22,247.1	680.9
14	Colorado Agricultural College	Korndyke Sarcastic Jolie 2nd	22,717.8	666.3
15	North Dakota Agricultural College	Miss Ormsby Queen	17,718.7	640.1
16	Oregon Agricultural College	Princess Lill De Kol	16,249.0	598.0
17	West Virginia University	Schulings Beauty De Kol	15,002.0	522.9
18	University of Arkansas	Madison Jennie Friend	18,873.7	512.9
19	University of Maine	Sophie Shepherd De Kol 2nd	14,192.0	503.0
20	University of Tennessee	Violet Houwje Lady	14,470.1	490.3
21	University of Kentucky	Jr. De Kol Betsy	15,000.8	456.8
22	Clemson Agricultural College (S. C.)	Dotty Pontiac De Kol	13,160.7	427.7
23	University of Missouri	No entry		
24	University of Maryland	No Holsteins		

Holsteins—Continued

RANK	OWNER	COW	MILK	FAT
Senior four year old class				
			pounds	*pounds*
1	University of Illinois	Juna Longfield Homestead	24,655.5	828.5
2	University of Missouri	Campus Josephine Galaxy	20,510.0	702 0
3	Kansas State Agricultural College	Carlotta Empress Fobes	24,547 0	694.2
4	Virginia Polytechnic Institute	Veeman Korndyke De Kol	19,620.0	687 0
5	University of California	Colantha 4th's Lad Mercedes	17,161.5	613.2
6	Connecticut Agricultural College	Minnie Fay Pietertje	20,822 8	607 5
7	Pennsylvania State College	Jessie Korndyke Verbelle	18,166 4	583.1
8	University of Nebraska	Quavia Lincoln	16,980 8	582.2
9	University of Maine	Pauline Pontiac Shepherd	15,759 0	581.0
10	University of Idaho	Idaho Favorite	18,367.8	574.6
11	University of Minnesota	Sita De Kol Pontiac	16,211.0	567.0
12	Iowa State College	Lucy Duchess De Kol	16,994.9	552.7
13	New Jersey Agricultural College	Rutgers' Duchess De Kol Korndyke	18,090.7	537.3
14	Purdue University	Colantha Paul Beet's Bakker	16,736.0	510.0
15	University of Arkansas	Dallas Friend Madison Jennie	14,604 0	497.1
16	Oregon Agricultural College	Oregon Korndaw	13,216 0	477.8
17	University of Tennessee	Winona Colantha 2nd	11,261.2	436 7
18	North Dakota Agricultural College	Cynthia Lass Ormsby	13,018.4	412.4
19	University of Kentucky	Duchess Rose De Kol 4th	10,481.2	357 6
20	Clemson Agricultural College (S. C.)	No entry		
21	Colorado Agricultural College	No entry		
22	University of West Virginia	No entry		
23	Massachusetts Agricultural College	No entry		
24	University of Maryland	No Holsteins		

Holsteins—Continued

RANK	OWNER	COW	MILK	FAT
Junior four year old class				
			pounds	*pounds*
1	Virginia Polytechnic Institute	V. P. I. Veeman De Kol	17,333.0	764.0
2	University of Nebraska	Kittie Gerben Lincoln	18,382.1	718.0
3	University of California	Pietertje Lorena Korndyke	18,602.4	630.3
4	Connecticut Agricultural College	Dorinda Storrs De Kol	18,523.1	623.6
5	Massachusetts Agricultural College	Concord Woodcrest Fayne	17,680.0	622.0
6	University of Idaho	Ormsby Girl 2nd	16,724.6	621.4
7	University of Minnesota	Viola Longfield Sir Beets	19,893.0	567.0
8	Pennsylvania State College	Queen Pontiac Inka	14,747.0	567.0
9	University of West Virginia	Hulda Isabel Tula	17,422.3	538.0
10	Iowa State College	Belle Polkadot Pontiac Lass	16,823.3	536.6
11	University of Maine	Rebecca Empress Johanna	16,434.0	534.0
12	Purdue University	Princess Mercedes Segis	16,908.0	528.0
13	Colorado Agricultural College	Collins Chloe 3rd	16,703.7	518.0
14	Kansas State Agricultural College	Maid Henry Pontiac	14,502.0	514.7
15	University of Illinois	Pietertje Parthenea Sarcastic	15,937.2	510.7
16	Clemson Agricultural College (S. C.)	Mutual Maid Clothilde	16,100.0	497.1
17	Oregon Agricultural College	Loa Belle	13,045.0	496.9
18	University of Tennessee	Winona Colantha Lass	11,598.8	422.4
19	University of Kentucky	Aaggie Betsy Cornucopia	11,285.8	386.2
20	University of Arkansas	No entry		
21	North Dakota Agricultural College	No entry		
22	New Jersey Agricultural College	No entry		
23	University of Missouri	No entry		
24	University of Maryland	No Holsteins		

Holsteins—Continued

RANK	OWNER	COW	MILK	FAT
		Senior three year old class		
			pounds	*pounds*
1	University of California	California Agnes Colantha	19,409.6	689.9
2	University of Nebraska	Roxeva Lincoln	19,391.3	673.1
3	University of Tennessee	Violet Houwje Lady	15,408.6	630.4
4	Virginia Polytechnic Institute	V. P. I. Dione Korndyke Girl	19,984.0	600.0
5	Massachusetts Agricultural College	Beth Blossom Fayne	17,144.0	575.0
6	Kansas State Agricultural College	Lady Vale Walker	17,004.0	564.5
7	Pennsylvania State College	Jessie Natalie Korndyke Pontiac	16,365.6	530.4
8	Connecticut Agricultural College	Minnie Fay Pietertje	17,020.0	525.3
9	University of Minnesota	Anna Grace Lady De Kol	14,472.7	499.3
10	University of Missouri	Campus Lady Hengerveld Uno	13,256.0	496.0
11	Clemson Agricultural College (S. C.)	Helen Queen Ona	12,796.0	472.2
12	Iowa State College	Nutula Alcartra Pietertje Bakker	14,484.9	471.8
13	University of West Virginia	Violet Courtland Butterboy	11,990.0	461.9
14	Purdue University	Colantha Paul Beet's Bakker	15,037.0	445.0
15	Colorado Agricultural College	Korndyke Sarcastic Jolie 2nd	14,714.9	428.8
16	North Dakota Agricultural College	Miss Ormsby Madeline	12,531.7	419.8
17	Oregon Agricultural College	Hazel Queen	13,592.0	402.5
18	University of Idaho	Cinderella Korndyke Hengerveld	10,290.2	366.6
19	University of Arkansas	No entry		
20	University of Illinois	No entry		
21	New Jersey Agricultural College	No entry		
22	University of Kentucky	No entry		
23	University of Maine	No entry		
24	University of Maryland	No Holsteins		

Holsteins—Continued

RANK	OWNER	COW	MILK	FAT
	Junior three year old class			
			pounds	*pounds*
1	University of Illinois	Illini Dulcina De Kol	17,755.4	719.7
2	Virginia Polytechnic Institute	V. P. I. Mineta	16,055.0	673.0
3	Connecticut Agricultural College	Pietertje De Kol Burke 2nd	18,850.2	661.4
4	New Jersey Agricultural College	Rutgers' Beauty Korndyke	16,307.2	628.5
5	University of Nebraska	Katy Gerben	18,573.4	620.4
6	University of Minnesota	Cyme Aaggie Beets of Shady Nook	18,611.0	611.0
7	University of California	California Juliana De Kol 2nd	16,618.1	598.4
8	Pennsylvania State College	Jessie Colantha Pontiac Korndyke	18,719.9	569.2
9	Iowa State College	Princess Pontiac of Ames	14,787.3	513.8
10	University of Idaho	Idaho Violet Daisy De Kol	14,358.6	509.4
11	Massachusetts Agricultural College	Piebe Clay Hengerveld Johanna	16,622.0	508.0
12	University of Arkansas	Naudine Pontiac Snowball Netherlands 2nd	14,672.0	474.9
13	University of West Virginia	Schulings' Beauty De Kol	15,115.1	469.2
14	Kansas State Agricultural College	Canary College Josephine	13,581.0	449.9
15	University of Tennessee	Winona Colantha Lass	9,859.2	352.0
16	North Dakota Agricultural College	Ormsby Lass Hengerveld	10,434.9	351.5
17	Clemson Agricultural College (S. C.)	McKinley Tehee Clothilde	11,326.0	299.4
18	Colorado Agricultural College	No entry		
19	University of Kentucky	No entry		
20	University of Maine	No entry		
21	University of Missouri	No entry		
22	Oregon Agricultural College	No entry		
23	Purdue University	No entry		
24	University of Maryland	No Holsteins		

Holsteins—Continued

Senior two year old class

RANK	OWNER	COW	MILK	FAT
			pounds	*pounds*
1	University of California	California Pietertje Bloom Mead	19,985.0	722.2
2	University of Illinois	Illini Homestead Parthenia Girl	20,393.5	717.0
3	Virginia Polytechnic Institute	V. P. I. Veeman Korndyke De Kol	20,696.0	675.0
4	University of Nebraska	Roxeva Lincoln	17,625.5	586.4
5	Kansas State Agricultural College	Inka Hijlaard Walker	16,058.0	585.4
6	Iowa State College	Miss Fayne Ames Gamma	17,068.5	571.7
7	University of Minnesota	Colantha Ormsby Korndyke Monroe	15,224.6	566.5
8	Pennsylvania State College	Keystone De Kol Pietertje Beets	16,182.8	562.4
9	University of Tennessee	Lady Woodcrest Colantha Lad	13,293.6	504.5
10	University of Idaho	Idaho Segis Ormsby Girl	13,870.9	478.4
11	Purdue University	Inka Colantha Segis	15,631.0	465.0
12	Colorado Agricultural College	Barbara Duchess Clyde 3rd	14,398.9	456.1
13	Oregon Agricultural College	Oregon Daw De Kol	12,618.0	452.9
14	Connecticut Agricultural College	Dorinda Storrs De Kol	12,846.0	441.5
15	University of Arkansas	Arkansas Tidy Jennie Beets	13,475.0	424.6
16	North Dakota Agricultural College	Miss Ormsby Queen Farewell	12,473.0	422.0
17	Massachusetts Agricultural College	Countess Chloe	12,037.0	401.0
18	Clemson Agricultural College (S. C.)	Mutual Maid Clothilde	11,653.0	370.6
19	University of Missouri	Campus Lady Hengerveld Dorabel	12,752.0	366.0
20	University of Kentucky	No entry		
21	University of Maine	No entry		
22	New Jersey Agricultural College	No entry		
23	University of West Virginia	No entry		
24	University of Maryland	No Holsteins		

Holsteins—Continued

RANK	OWNER	COW	MILK	FAT
		Junior two year old class		
			pounds	*pounds*
1	University of Minnesota	Fairy Aaggie Korndyke Colantha	20,005.5	696.8
2	University of Nebraska	Varsity Derby Sultana	19,555.8	693.5
3	University of Illinois	Illini Tritomia Tina Clay	18,909.4	592.9
4	Virginia Polytechnic Institute	V. P. I. Dione De Kol	12,444.1	544.0
5	New Jersey Agricultural College	Rutgers' Valdessa Beauty	15,590.5	527.7
6	Massachusetts Agricultural College	Concordia Fayne Pietertje	14,870.0	486.0
7	University of Idaho	Idaho Segis Colantha	13,004.9	470.4
8	University of California	Pietertje Bloom 2nd	13,216.1	460.7
9	Pennsylvania State College	Pennstates Ormsby Pontiac	13,181.5	457.4
10	Iowa State College	Johanna Fayne Pride of Ames	14,586.0	455.7
11	University of Arkansas	Arkansas Segis Topsy	14,429.0	453.2
12	Oregon Agricultural College	Lois Lill De Kol	11,865.0	433.0
13	Purdue University	Purdue Segis Colantha Princess	14,981.0	416.0
14	University of Missouri	Campus Lady Hengerveld Bluebell	11,127.0	412.0
15	Kansas State Agricultural College	Netherland Omnis Walker	12,243.0	411.5
16	North Dakota Agricultural College	Miss Ormsby Hengerveld	11,715.0	399.8
17	Clemson Agricultural College (S. C.)	Helen Queen Minnehaha	11,508.7	372.8
18	University of Kentucky	Duchess Pietertje Rose	10,182.2	341.1
19	University of Tennessee	Houwtje Pietertje De Kol Lady	8,788.3	318.0
20	Connecticut Agricultural College	De Kol Hubbard Pietertje 2nd	8,156.4	306.1
21	University of West Virginia	Queen Klassje De Kol	8,892.4	297.8
22*	Colorado Agricultural College	Chloe Korndyke Clothilde	9,258.6	292.6
23	University of Maine	No entry		
24	University of Maryland	No Holsteins		

* Senior yearling.

Jerseys

Mature class

RANK	OWNER	COW	MILK	FAT
			pounds	*pounds*
1	University of Illinois	Majesty's Iris	17,469.7	955.8
2	University of California	Interested Jap's Santa	15,569.0	940.7
3	Oregon Agricultural College	Old Man's Darling	14,130.0	818.0
4	Connecticut Agricultural College	Beaudesert Pet	13,870.1	762.8
5	Purdue University	Purdue's Golden Estelle	14,052.0	748.0
6	University of Maine	Lassie of M. F.	10,000.0	690.0
7	Iowa State College	Figgis 28th of Hood Farm	12,131.0	675.0
8	University of Minnesota	Lads' Goldy Y	12,187.0	669.0
9	Kansas State College	The Owl's Design	14,606.0	650.1
10	Massachusetts Agricultural College	Jeanette of Hebron	12,487.0	643.0
11	North Dakota Agricultural College	Roxana Maid	11,981.1	640.2
12	University of Tennessee	Major's Fancy Tormentress	10,484.0	632.0
13	University of Nebraska	Bona Lincoln	12,691.0	628.0
14	New Jersey Agricultural College	Lady Leifburrow of Oak Hill	11,277.5	624.5
15	Clemson Agricultural College (S. C.)	Plumage Inez	10,202.0	559.3
16	University of Arkansas	Cynthia's Golden Babe	10,798.5	550.8
17	University of Missouri	Campus Virginia J	8,963.0	491.0
18	University of Kentucky	Baronette's Lady Dean	7,778.8	442.4
19	Colorado Agricultural College	No entry		
20	University of Idaho	No entry		
21	Pennsylvania State College	No entry		
22	Virginia Polytechnic Institute	No entry		
23	West Virginia University	No entry		
24	University of Maryland	No Jerseys		

Senior four year old class

RANK	OWNER	COW	MILK	FAT
1	Massachusetts Agricultural College	Lass Princess	10,808.0	701.0
2	University of Maine	Lakeland's Lassie	11,700.0	660.0
3	Iowa State College	Princess Figgis of Ames	11,408.0	641.8
4	University of Nebraska	Reba Lincoln	10,667.0	618.0

Jerseys—Continued

RANK	OWNER	COW	MILK	FAT
	Senior four year old class—*Continued*			
			pounds	*pounds*
5	Oregon Agricultural College	Sophie's Golden Glow Beauty	10,827.0	617.7
6	Kansas State Agricultural College	Khoi	12,518.0	615.2
7	University of Missouri	Campus Virginia L	9,387 0	603.0
8	New Jersey Agricultural College	Rutger's Oxford Marvel	13,984 0	591.5
9	University of California	California Jap's Nora	10,528.0	546.6
10	University of Arkansas	Pearl's Alpha	10,550 0	531.0
11	Connecticut Agricultural College	Storr's Select Butterfly	8,723.2	509.7
12	Purdue University	Purdue's Sayda	9,119 0	467.0
13	University of Tennessee	Fancy Evolution	6,426.0	356.0
14	University of Kentucky	Hebron's Lady	6,366 2	352.5
15	Clemson Agricultural College	University Lad's Violet	6,975 4	352.32
16	Colorado Agricultural College	No entry		
17	University of Idaho	No entry		
18	University of Illinois	No entry		
19	University of Minnesota	No entry		
20	North Dakota Agricultural College	No entry		
21	Pennsylvania State College	No entry		
22	Virginia Polytechnic Institute	No entry		
23	West Virginia University	No entry		
24	University of Maryland	No Jerseys		
	Junior four year old class			
1	University of California	Interested Jap's Santa	13,308.5	805.72
2	University of Missouri	Campus Virginia Q	11,154.0	623.0
3	University of Maine	Poet's Golden Flora	11,355.0	610.0
4	University of Kentucky	Dollie's Valentine	10,218.0	578.0
5	Iowa State College	Raleigh's Maiden of Ames	12,107.0	543.8
6	University of Nebraska	Ella Lincoln	10,850.0	531.0
7	Purdue University	Lady Sayda Mary	9,167.0	531.0
8	Kansas State Agricultural College	Docter's Lady Love.	9,913.0	495.1
9	Connecticut Agricultural College	Storrs' Robin Butterfly	8,627.0	490 1

Jerseys - Continued

RANK	OWNER	COW	MILK	FAT
	Junior four year class—*Continued*			
			pounds	*pounds*
10	University of Idaho	Eagle's Golden Princess	5,821.1	349.3
11	University of Arkansas	Eminent's Rosaline	6,930.0	336.5
12	Colorado Agricultural College	No entry		
13	University of Illinois	No entry		
14	Massachusetts Agricultural College	No entry		
15	University of Minnesota	No entry		
16	New Jersey Agricultural College	No entry		
17	North Dakota Agricultural College	No entry		
18	Oregon Agriculture College	No entry		
19	Pennsylvania State College	No entry		
20	Clemson Agricultural College (S. C.)	No entry		
21	University of Tennessee	No entry		
22	Virginia Polytechnic Institute	No entry		
23	West Virginia University	No entry		
24	University of Maryland	No Jerseys		
	Senior three year old class			
1	Oregon Agricultural College	Oregon Maple G	10,776.0	650.2
2	Purdue University	Estelle Joan	10,632.0	633.0
3	University of Illinois	Volunteer's Juliet	12,286.0	614.1
4	University of California	California Inside	9,991.8	590.8
5	University of Maine	Lakeland's Lassie	9,391.0	556.0
6	University of Arkansas	Pearl's Alpha	10,239.6	553.84
7	Kansas Agricultural College	Sultana's Jolly Tipsy	9,201.0	541.3
8	Iowa State College	Ames Financial Beauty	10,381.0	529.6
9	University of Nebraska	Ula Lincoln	9,311.0	520.0
10	New Jersey Agricultural College	Mandy Matchless Queen	8,666.3	510.1
11	Connecticut Agricultural College	Copper Butterfly 2nd	8,837.5	454.0

Jerseys—Continued

RANK	OWNER	COW	MILK	FAT
	Senior three year old class—*Continued*			
			pounds	*pounds*
12	Clemson Agricultural College (S. C.)	University Plymouth Belle	8,872.7	450.3
13	West Virginia University	Nellie's Little Queenie	9,142.9	447.7
14	University of Idaho	Eagle's Jersey Queen	6,484.9	395.3
15	University of Kentucky	Raleigh's Countess	7,871.3	378.8
16	Colorado Agricultural College	No entry		
17	Massachusetts Agricultural College	No entry		
18	University of Minnesota	No entry		
19	University of Missouri	No entry		
20	Pennsylvania State College	No entry		
21	University of Tennessee	No entry		
22	North Dakota Agricultural College	No entry		
23	Virginia Polytechnic Institute	No entry		
24	University of Maryland	No Jerseys		
	Junior three year old class			
1	University of Minnesota	Trill Pogis of Lily Dale	12,159.0	682.0
2	Connecticut Agricultural College	Beaudesert Pet	11,806.0	610.0
3	University of Missouri	Campus Virginia Q	8,294.0	468.0
4	University of California	Mermaiden Fern 2nd	9,110.0	466.0
5	Iowa State College	Pogis Belle of Ames	9,320.0	456.8
6	Purdue University	Purdue's Evening Primrose	9,858.0	454.0
7	Clemson Agricultural College	Pogis Princess of P. V. Farms	10,005.0	435.5
8	North Dakota Agricultural College	Dodo's Silverine	7,092.9	428.9
9	University of Arkansas	Eminent's Cynthia	7,026.6	424.4
10	Kansas State Agricultural College	Sultana's Noble Revelation	7,429.0	413.7
11	University of Nebraska	Elaine Lincoln	7,220.0	408.0
12	Oregon Agricultural College	Oregon Maple F	7,304.0	399.0
13	University of Kentucky	Baronette's Golden McEachen	6,958.8	397.3

Jerseys—Continued

RANK	OWNER	COW	MILK	FAT
	Junior three year old class—*Continued*			
			pounds	*pounds*
14	West Virginia University	Emma's Pleasure	8,026.0	387.8
15	University of Tennessee	Cherokee Anne	6,589 0	346.2
16	University of Idaho	Owl's Traviata of Waikiki	6,414 0	335 4
17	Colorado Agricultural College	No entry		
18	University of Illinois	No entry		
19	University of Maine	No entry		
20	Massachusetts Agricultural College	No entry		
21	New Jersey Agricultural College	No entry		
22	Pennsylvania State College	No entry		
23	Virginia Polytechnic Institute	No entry		
24	University of Maryland	No Jerseys		
	Senior two year old class			
1	University of California	Interested Jap's Santa	9,051 0	588.2
2	Oregon Agricultural College	Oregon Tormentor Glow	10,710 0	587 6
3	New Jersey Agricultural College	Rutger's Fern Clara	9,625 0	557.4
4	University of Missouri	Campus Virginia T	9,086 0	489 0
5	Pennsylvania State College	Pogis Romona of Old Forge	8,090 5	476.9
6	University of Kentucky	Hebron's Betty	8,334 0	414.5
7	Iowa State College	Raleigh's Maiden of Ames	8,926 0	404 6
8	University of Illinois	Volunteer's Juliet	7,156.0	370 7
9	Clemson Agricultural College	Plymouth Queen Nora	6,894.6	362.4
10	Connecticut Agricultural College	Storrs Althea	6,733.1	340.6
11	University of Nebraska	Glory Lincoln	5,561.0	336.0
12	University of Tennessee	Jolly's Eminent Isis	6,408.0	333.6
13	North Dakota Agricultural College	College Marietta	7,067.5	327.1
14	University of Arkansas	Cynthia's Golden Babe	6,428.1	322.1
15	University of Minnesota	Elayne Oxford of Lily Dale	5,982 0	288 0
16	Colorado Agricultural College	No entry		

Jerseys—Continued

RANK	OWNER	COW	MILK	FAT
	Senior two year old class—*Continued*			
			pounds	*pounds*
17	University of Idaho	No entry		
18	Kansas State Agricultural College	No entry		
19	University of Maine	No entry		
20	Massachusetts Agricultural College	No entry		
21	Purdue University	No entry		
22	Virginia Polytechnic Instiute	No entry		
23	West Virginia University	No entry		
24	University of Maryland	No Jerseys		
	Junior two year old class			
1	Pennsylvania State College	Penstate's Torono's Blacky	9,854.7	532.3
2	Oregon Agricultural College	Oregon Sweet Glow	9,740.0	525.5
3	University of Missouri	Campus Virginia S	7,829.0	492.0
4	Iowa State College	Ames Financial Beauty	9,611.0	475.2
5	University of California	California's Owl's Rose	7,773.6	475.1
6	University of Nebraska	Elma Lincoln	9,185.0	468.0
7	Kansas State Agricultural College	Sultana's Jolly Tipsy	7,940.0	464.9
8	University of Illinois	Majesty's Iris 2nd	8,024.4	450.9
9	University of Idaho	Idaho Blossom	7,650.7	443.2
10	University of Kentucky	Hebron's Tera B	8,759.6	425.7
11	Purdue University	Purdue's Evening Primrose	8,799.0	419.0
12	Clemson Agricultural College	Blue Foxes' Golden Trover	9,141.0	414.3
13	Connecticut Agricultual College	Copper Butterfly 2nd	7,770.7	403.4
14	North Dakota Agricultural College	Roxanna Daisy	7,338.6	376.2
15	University of Arkansas	Arkansas Fairy 2nd	7,713.0	373.2
16	University of Minnesota	Tylene Oxford of Lily Dale	6,195.0	352.0
17	Colorado Agricultural College	Sans Aloi Rosette	6,623.0	315.8
18	University of Maine	Lassie of M. F.	4,596.0	306.0

Jerseys—Continued

Junior two year old class—*Continued*

RANK	OWNER	COW	MILK	FAT
			pounds	*pounds*
19	University of Tennessee	Blue Belle of Meadow Brook	4,902.0	261.2
20	Massachusetts Agricultural College	No entry		
21	New Jersey Agricultual College	No entry		
22	Virginia Polytechnic Institute	No entry		
23	West Virginia University	No entry		
24	University of Maryland	No Jerseys		

Guernseys

Mature cow class

RANK	OWNER	COW	MILK	FAT
1	University of Illinois	Yeksarose 4th	14,527.1	753.7
2	University of California	Fern Ridge Rose	17,062.0	729.5
3	Massachusetts Agricultual College	Earl's Nantaska	13,355.0	704.0
4	Oregon Agricultural College	May Rose IX of la Masse	13,174.0	696.1
5	Kansas State Agricultural College	Imp Pallas	13,240.0	624.8
6	University of Minnesota	Yexeve of Ash Cove	12,188.0	619.0
7	Iowa State College	Miss of St. Louis 2nd	12,101.5	618.7
8	University of Nebraska	Squire des Blicqs's Helene	11,346.0	592.0
9	University of Maryland	Elfleda of Haddon	14,093.0	583.0
10	Connecticut Agricultural College	Lorm Masher	11,357.4	558.7
11	North Dakota Agricultural College	Yeksa Sunbeam 2nd	9,924.9	487.4
12	University of Maine	Canada's Crensa 2nd	10,631.0	470.0
13	Clemson Agricultural College (S. C.)	No entry		
14	Colorado Agricultural College	No entry		
15	University of Kentucky	No entry		
16	New Jersey Agr. College	No entry		
17	University of Missouri	No entry		
18	Pennsylvania State College	No entry		

Guernseys—Continued

RANK	OWNER	COW	MILK	FAT
	Mature cow class—*Continued*			
			pounds	*pounds*
19	Purdue University (Ind.)	No entry		
20	Virginia Polytechnic Institute	No entry		
21	West Virginia University	No Guernseys		
22	University of Idaho	No Guernseys		
23	University of Arkansas	No Guernseys		
24	University of Tennessee	No Guernseys		
	Senior four year old class			
1	Massachusetts Agricultural College	College King's Nantaska	14,811.0	684.0
2	Iowa State College	Rouge II of the Brickfield	12,205.9	608.1
3	North Dakota Agricultural College	Yeksa Proud	7,936.0	461.3
4	University of Maryland	Procida's Poinsetta	9,952.0	425.0
5	Purdue University	Imp. Rosetta III of Anevilles	8,879.0	422.0
6	Oregon Agricultural College	Alcina of Upper Freehold	7,359.0	390.7
7	Colorado Agricultural College	Orlette's Fancy Lassie	8,017.0	381.9
8	Connecticut Agricultural College	Eurotas Mansfield 2nd	9,225.0	359.5
9	University of Nebraska	Princess Lincoln	7,849.0	347.0
10	University of California	No entry		
11	Clemson Agricultural College	No entry		
12	University of Illinois	No entry		
13	Kansas State Agricultural College	No entry		
14	University of Kentucky	No entry		
15	University of Maine	No entry		
16	University of Minnesota	No entry		
17	University of Missouri	No entry		
18	New Jersey Agricultural College	No entry		
19	Pennsylvania State College	No entry		
20	Virginia Polytechnic Institute	No entry		
21	University of Arkansas	No Guernseys		

Guernseys—Continued

RANK	OWNER	COW	MILK	FAT
	Senior four year old class—*Continued*			
			pounds	*pounds*
22	University of Idaho	No Guernseys		
23	University of Tennessee	No Guernseys		
24	University of West Virginia	No Guernseys		
	Junior four year old class			
1	Pennsylvania State College	Delza 3rd	10,608.7	542.5
2	Kansas State Agricultural College	Imp. Lucy II of Carbinez	10,599.0	532.7
3	University of Maine	Lake Grove Lucretia	8,228.0	452.0
4	University of Illinois	Jeydale 3rd	8,797.6	430.0
5	Iowa State College	Imp. Princess 2nd of the Blicqs	8,853.3	428.7
6	University of Nebraska	Pearl Lincoln	9,408.0	428.0
7	University of California	Fern Ridge Pearl	8,241.5	398.5
8	Oregon Agricultural College	Little Nell of Foothill's Farm	7,628.0	331.8
9	Clemson Agricultural College	No entry		
10	Colorado Agricultural College	No entry		
11	Connecticut Agricultural College	No entry		
12	University of Kentucky	No entry		
13	University of Maryland	No entry		
14	Massachusetts Agricultural College	No entry		
15	University of Minnesota	No entry		
16	University of Missouri	No entry		
17	New Jersey Agricultural College	No entry		
18	North Dakota Agricultural College	No entry		
19	Purdue University	No entry		
20	Virginia Polytechnic Institute	No entry		
21	University of Arkansas	No Guernseys		
22	University of Idaho	No Guernseys		
23	University of Tennessee	No Guernseys		
24	University of West Virginia	No Guernseys		

Guernseys—Continued

RANK	OWNER	COW	MILK	FAT
Senior three year old class				
			pounds	*pounds*
1	Massachusetts Agricultural College	Nantaska Beauty	11,359.0	608.0
2	University of Illinois	Yeksarose 4th	11,904.4	602.7
3	University of Nebraska	Squire des Blicqs's Helene	10,577.0	559.0
4	Connecticut Agricultural College	Lorin Masher	10,632.4	529.3
5	Colorado Agricultural College	Dolly Bonits	10,044.2	476.9
6	Iowa State College	Imp. Parson's Spot III	9,002.6	411.3
7	Kansas State Agricultural College	Imp. Donnington Happy Girl 7th	7,598 0	374.4
8	University of Maryland	Peggy of Rossbourg	7,311.0	352.0
9	University of California	No entry		
10	Clemson Agricultural College	No entry		
11	University of Kentucky	No entry		
12	University of Maine	No entry		
13	University of Minnesota	No entry		
14	University of Missouri	No entry		
15	North Dakota Agricultural College	No entry		
16	Oregon Agricultural College	No entry		
17	Pennsylvania State College	No entry		
18	Purdue University	No entry		
19	Virginia Polytechnic Institute	No entry		
20	New Jersey Agricultural College	No entry		
21	University of Arkansas	No Guernseys		
22	University of Idaho	No Guernseys		
23	University of Tennessee	No Guernseys		
24	University of West Virginia	No Guernseys		
Junior three year old class				
1	University of Nebraska	Squire des Blicqs's Ramona	10,672.0	501.0
2	University of Maine	Canada's Crensa 3rd	8,611.0	438.0
3	University of California	Fern Ridge Rose	9,928.8	436.4

Guernseys—Continued

RANK	OWNER	COW	MILK	FAT
	Junior three year old class—*Continued*			
			pounds	*pounds*
4	Connecticut Agricultural College	Lute Storr's Masher	8,029.7	433.3
5	University of Maryland	Procida of Rossbourg	9,412.0	422.0
6	Purdue University	Imp. Betty's Prize	7,049.0	391.0
7	North Dakota Agricultural College	Yeksa Proud	6,913.0	382.4
8	Iowa State College	Miss St. Louis of Ames	6,920.9	376.7
9	Oregon Agricultural College	Freesia's Corona Lass	7,872.0	363.4
10	Clemson Agricultural College	No entry		
11	Colorado Agricultural College	No entry		
12	University of Illinois	No entry		
13	Kansas State Agricultural College	No entry		
14	University of Kentucky	No entry		
15	Massachusetts Agricultural College	No entry		
16	University of Minnesota	No entry		
17	University of Missouri	No entry		
18	New Jersey Agricultural College	No entry		
19	Pennsylvania State College	No entry		
20	Virginia Polytechnic College	No entry		
21	University of Arkansas	No Guernseys		
22	University of Idaho	No Guernseys		
23	University of Tennessee	No Guernseys		
24	University of West Virginia	No Guernseys		
	Senior two year old class			
1	Iowa State College	Imp. Rouge II of the Brickfield	10,963.0	612.5
2	Kansas State Agricultural College	Bernice's Countess 2nd	9,991.0	521.8
3	Massachusetts Agricultural College	Imp. Bijou of Linda Vista	9,507.0	485.0
4	University of Maine	Crensa's Belle	7,502.0	444.0

Guernseys—Continued

RANK	OWNER	COW	MILK	FAT
	Senior two year old class—*Continued*			
			pounds	*pounds*
5	Clemson Agricultural College	Pet's Soso	7,523.8	423.0
6	University of Minnesota	Lil of Beirnetown	8,313.0	375.0
7	North Dakota Agricultural College	Yeksa Sunburst 2nd	7,510.4	354.1
8	Purdue University	Imp. Jeanette of Seignerrie	6,879.0	354.0
9	University of Maryland	Selma of Rossbourg	7,091.0	325.0
10	Connecticut Agricultural College	Eurotes Mansfield 2nd	6,911.4	294.8
11	University of California	No entry		
12	University of Colorado	No entry		
13	University of Illinois	No entry		
14	University of Kentucky	No entry		
15	University of Missouri	No entry		
16	New Jersey Agricultural College	No entry		
17	University of Nebraska	No entry		
18	Oregon Agricultural College	No entry		
19	Pennsylvania State College	No entry		
20	Virginia Polytechnic Institute	No entry		
21	University of Arkansas	No Guernseys		
22	University of Idaho	No Guernseys		
23	University of Tennessee	No Guernseys		
24	University of West Virginia	No Guernseys		
	Junior two year old class			
1	Clemson Agricultural College (S. C.)	May King's Alvada	12,294.9	538.0
2	Iowa State College	Ames Rouge Lassie	8,966.6	512.9
3	University of Maryland	Royal Lady of Oakhurst	9,008.0	507.0
4	University of Illinois	Miranda Pride of Oberland	9,360.9	505.2
5	University of Minnesota	Le Gele's Prairie Side Bell	10,124.0	474.0
6	University of Kentucky	Ladbelle of Sunnyside	7,596.3	434.3
7	Pennsylvania State College	Glow of Cloverdell	8,741.1	424.7
8	Kansas State Agricultural College	Imp. Lucy II of Corbinez	8,133.0	422.9

Guernseys—Continued

Junior two year old class—*Continued*

RANK	OWNER	COW	MILK	FAT
			pounds	*pounds*
9	University of California	California Pearl	7,652.5	389.7
10	University of Nebraska	Squire des Blicqs's Helene	7,602.0	383.0
11	Connecticut Agricultural College	Lute Storr's Masher	7,067.0	356.6
12	North Dakota Agricultural College	King Masher's Martha	7,111.6	353.3
13	Colorado Agricultural College	Orlette's Fancy Lassie	6,322.1	341.6
14	Purdue University	Imp. Betty's Prize	6,314.0	316.0
15	Oregon Agricultural College	Freesia's Corona Lass of Iowa	6,711.0	298.0
16	University of Maine	No entry		
17	Massachusetts Agricultural College	No entry		
18	University of Missouri	No entry		
19	New Jersey Agr. College	No entry		
20	Virginia Polytechnic Institute	No entry		
21	University of Arkansas	No Guernseys		
22	University of Idaho	No Guernseys		
23	University of Tennessee	No Guernseys		
24	University of West Virginia	No Guernseys		

Ayrshires

Mature cow class

1	Kansas State Agricultural College	Canary Bell	19,863.0	744.51
2	University of Illinois	Bluebell of the Plains	15,122.0	724.53
3	Massachusetts Agricultural College	Spot Fox	17,749.0	634.0
4	Connecticut Agricultural College	Mauchlin Snowdrop 2nd	14,680.0	618.53
5	University of Nebraska	Bonnie Jean	13,062.0	579.0
6	University of California	Willowmoor Cherry	12,601.0	551.4
7	Purdue University	Bangora's Fizzaway Pearl	15,000.0	545.0
8	Iowa State College	Cavalier's Belle of Spring City	13,434.0	515.2
9	University of Arkansas	College Lass	11,393.0	499.0
10	Oregon Agricultural College	Willowmoor White Pride B	12,234.0	482.4

Ayrshires—Continued

RANK	OWNER	COW	MILK	FAT
		Mature cow class—*Continued*		
			pounds	*pounds*
11	West Virginia University	Molly Ostrum	10,762 2	429.7
12	University of Minnesota			420.0
13	University of Maine	Envious Athenia	9,337.0	392.0
14	University of Maryland	Salome of Spring Valley	11,600.0	390 0
15	New Jersey Agricultural College	No entry		
16	Pennsylvania State College	No entry		
17	University of Missouri	No entry		
18	Virginia Polytechnic Institute	No entry		
19	Clemson Agricultural College (S. C.)	No Ayrshires		
20	Colorado Agricultural College	No Ayrshires		
21	University of Idaho	No Ayrshires		
22	University of Kentucky	No Ayreshires		
23	University of Tennessee	No Ayrshires		
24	North Dakota Agricultural College	No Ayrshires		
		Senior four year old class		
1	Purdue University	Bangora's Fizzaway	14,983.0	532.0
2	Iowa State College	Robin Hood Cavalier's Lass	12,265.0	529.4
3	Connecticut Agricultural College	Mauchlin Whitehill True	11,894 6	518.5
4	Kansas State Agricultural College	Elisabeth of Juneau	14,953.0	480.9
5	Oregon Agricultural College	Willowmoor Douglas	11,454.0	463.8
6	University of California	Willowmoor Cherry	10,465.0	445.0
7	University of Illinois	Violet of the Plains	10,713.0	381.8
8	University of Arkansas	No entry		
9	University of Maine	No entry		
10	University of Maryland	No entry		
11	Massachusetts Agricultural College	No entry		
12	University of Minnesota	No entry		
13	New Jersey Agricultural College	No entry		
14	University of Nebraska	No entry		

Ayrshires—Continued

Senior four year old class—*Continued*

RANK	OWNER	COW	MILK	FAT
			pounds	*pounds*
15	Pennsylvania State College	No entry		
16	University of Missouri	No entry		
17	University of West Virginia	No entry		
18	Virginia Polytechnic Institute	No entry		
19	Clemson Agricultural College	No Ayrshires		
20	Colorado Agricultural College	No Ayrshires		
21	University of Idaho	No Ayrshires		
22	University of Kentucky	No Ayrshires		
23	University of Tennessee	No Ayrshires		
24	North Dakota Agricultural College	No Ayrshires		

Junior four year old class

RANK	OWNER	COW	MILK	FAT
1	Massachusetts Agricultural College	Victor's Beauty Lass	15,980.0	666.0
2	Kansas State Agricultural College	Bangora 2nd's Good Gift	13,695.0	547.6
3	Connecticut Agricultural College	Mauchlin Snowdrop 2nd	11,537.0	494.0
4	University of Maryland	Kitty Macs	11,910.0	491.0
5	University of Arkansas	Beauty's Aldena	11,117.0	457.8
6	Iowa State College	Barclay's Flash Girl	10,934.0	427.1
7	University of Nebraska	Celeaste Lincoln	8,220.0	377.0
8	Oregon Agricultural College	Mabel Chalmers	10,083.0	352.0
9	University of California	California Cherry	10,486.0	351.2
10	University of Illinois	Illini Bluebell of the Plains	8,241.0	340.6
11	University of Minnesota	No entry		
12	University of Maine	No entry		
13	New Jersey State College	No entry		
14	Pennsylvania State College	No entry		
15	Purdue University	No entry		
16	University of Missouri	No entry		
17	University of West Virginia	No entry		

Ayrshires—Continued

RANK	OWNER	COW	MILK	FAT
	Junior four year old class—*Continued*			
			pounds	*pounds*
18	Virginia Polytechnic Institute	No entry		
19	Clemson Agricultural College	No Ayrshires		
20	Colorado Agricultural College	No Ayrshires		
21	University of Idaho	No Ayrshires		
22	University of Kentucky	No Ayrshires		
23	University of Tennessee	No Ayrshires		
24	North Dakota Agricultural College	No Ayrshires		
	Senior three year old class			
1	Kansas State Agricultural College	Bangora's Melrose	14,515.0	568.1
2	Massachusetts Agricultural College	Norena's Violet	13,347.0	559.0
3	University of Maine	Majestic Netta	10,000.0	460.0
4	Connecticut Agricultural College	Mauchlin Whitehill True	8,739.2	428.6
5	Oregon Agricultural College	College Netherall Blonde	10,112.0	418.8
6	Pennsylvania State College	Penstates Finlayston Snowdrop	9,274.0	412.2
7	University of Arkansas	No entry		
8	University of California	No entry		
9	University of Illinois	No entry		
10	Iowa State College	No entry		
11	University of Maryland	No entry		
12	University of Minnesota	No entry		
13	New Jersey Agricultural College	No entry		
14	Purdue University (Indiana)	No entry		
15	University of Nebraska	No entry		
16	University of Missouri	No entry		
17	University of West Virginia	No entry		
18	Virginia Polytechnic Institute	No entry		

Ayrshires—Continued

RANK	OWNER	COW	MILK	FAT
	Senior three year old class—Continued			
			pounds	*pounds*
19	Clemson Agricultural College (S. C.)	No Ayrshires		
20	Colorado Agricultural College	No Ayrshires		
21	University of Idaho	No Ayrshires		
22	University of Kentucky	No Ayrshires		
23	University of Tennessee	No Ayrshires		
24	North Dakota Agricultural College	No Ayrshires		
	Junior three year old class			
1	Iowa State College	Cavalier's Robin Hood Lass	9,830.0	472.4
2	Oregon Agricultural College	Willowmoor White Pride B	10,736.0	441.8
3	Massachusetts Agricultural College	Beauty Chevlynn	10,387.0	433.0
4	University of Nebraska	Clemie Spencer	10,276.0	392.0
5	University of Maine	Wilson Valley Rhoda	8,991.0	370.0
6	Connecticut Agricultural College	Mauchlin Snowdrop 2nd	8,359.0	365.4
7	Purdue University	Bangora Pearl Croft	9,563.0	347.0
8	University of California	California Barcheskie	8,105.0	318.6
9	Kansas State Agricultural College	Kansas Croft Maude	8,442.0	314.9
10	University of Illinois	Cornflower	7,043.0	311.2
11	University of Arkansas	College Lass	7,095.0	308.4
12	University of Maryland	No entry		
13	University of Minnesota	No entry		
14	New Jersey Agricultural College	No entry		
15	Pennsylvania State College	No entry		
16	University of Missouri	No entry		
17	University of West Virginia	No entry		
18	Virginia Polytechnic Institute	No entry		
19	Clemson Agricultural College (S. C.)	No Ayrshires		
20	Colorado Agricultural College	No Ayrshires		

Ayrshires—Continued

RANK	OWNER	COW	MILK	FAT
Junior three year old class—*Continued*				
			pounds	*pounds*
21	University of Idaho	No Ayrshires		
22	University of Kentucky	No Ayrshires		
23	University of Tennessee	No Ayrshires		
24	North Dakota Agricultural College	No Ayrshires		
Senior two year old class				
1	University of Maryland	Juno of Rossbourg	12,371.0	537.0
2	Pennsylvania State College	Penstates Finlayston Bell	10,644.0	529.0
3	Massachusetts Agricultural College	Victor's Beauty Lass	12,664.0	521.0
4	Kansas State Agricultural College	Cavalier's Croft Melrose	12,499.0	467.5
5	Oregon Agricultural College	Oregon Panetta B	11,295.0	452.1
6	University of Missouri	Campus Canary E	8,850.0	392.0
7	University of Nebraska	Celeaste Lincoln	9,504.0	377.0
8	University of Maine	Majestic Netta	8,010.0	322.0
9	University of Illinois	Illini Bluebell of the Plains	7,281.0	314.7
10	University of Arkansas	No entry		
11	Connecticut Agricultural College	No entry		
12	University of California	No entry		
13	Iowa State College	No entry		
14	University of Minnesota	No entry		
15	New Jersey Agricultural College	No entry		
16	Purdue University	No entry		
17	Virginia Polytechnic Institute	No entry		
18	University of West Virginia	No entry		
19	Clemson Agricultural College	No Ayrshires		
20	Colorado Agricultural College	No Ayrshires		
21	University of Idaho	No Ayrshires		
22	University of Kentucky	No Ayrshires		
23	University of Tennessee	No Ayrshires		
24	North Dakota Agricultural College	No Ayrshires		

Ayrshires—Continued

RANK	OWNER	COW	MILK	FAT
	Junior two year old class			
			pounds	*pounds*
1	Kansas State Agricultural College	Melrose Canary Bell	13,785.0	502.9
2	Iowa State College	Ames Robin Hood Princess	10,600.0	467.2
3	Oregon Agricultural College	Oregon Panetta G	11,365.0	453.1
4	University of Maine	Majestic Girl of Orono	10,000.0	450.0
5	University of Maryland	Sunshine of Rossbourg	9,088.0	404.0
6	Connecticut Agricultural College	Mauchlin Snowdrop 2nd	8,050.0	357.8
7	University of California	California Barcheskie	7,859.0	352.3
8	University of Missouri	Campus Canary F	8,327.0	329.0
9	University of Nebraska	Bonalee B. Lincoln	6,878.0	323.0
10	Purdue University	Millie Woolford Fizzaway	7,265.0	265.0
11	University of Illinois	Violet of the Plains 2nd	6,731.0	260.9
12	University of Arkansas	No entry		
13	Massachusetts Agricultural College	No entry		
14	University of Minnesota	No entry		
15	New Jersey Agricultural College	No entry		
16	Pennsylvania State College	No entry		
17	Virginia Polytechnic Institute	No entry		
18	University of West Virginia	No entry		
19	Clemson Agricultural College	No Ayrshires		
20	Colorado Agricultural College	No Ayrshires		
21	University of Idaho	No Ayreshires		
22	University of Kentucky	No Ayrshires		
23	University of Tennessee	No Ayrshires		
24	North Dakota Agricultural College	No Ayrshires		

THE MINERAL REQUIREMENTS OF DAIRY COWS[1]

PRESENT STATUS OF THE QUESTION

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The discussion in this paper will be confined to the two elements, calcium and phosphorus. There is little reason to think that deficiencies of any other mineral elements play a very large or general practical rôle under ordinary conditions, except, perhaps, in the case of iodine. There is much evidence in existence which shows that in certain regions goitre develops in human beings as well as in farm animals as the result of an iodine deficiency in the food. But the discussion of this question is outside the scope of the present paper.

The subject of calcium and phosphorus deficiencies may be outlined under three questions.

I. Do deficiencies of calcium and phosphorus in the rations of dairy cows play an important practical part under present conditions of feeding?

II. Under what circumstances do such deficiencies occur?

III. How are they to be corrected?

I

The work of Forbes has probably done more to call attention to the possibility that dairy cows may often suffer from calcium and phosphorus deficiencies than that of any other recent investigator. Forbes has carried out approximately fifty experiments in which the calcium and phosphorus balances of dairy cows were determined (1). When the cows were giving liberal quantities of milk, the calcium balances were always negative; and the phosphorus balances, usually so. In most of the experiments the rations were not such as one would naturally expect to be deficient in either calcium or phosphorus. On the contrary, they contained large quantities of alfalfa or other legume hay and of such concentrates as wheat bran and cottonseed meal, which have a high phosphorus content. The cows which were fed on such rations and which gave 30 pounds of milk or more daily had an average negative calcium balance of 10 grams daily. A cow which continued to lose calcium at this rate for a year would have suffered a loss of more than 3.5 kgm. of calcium at the end of that period—more than half of all the calcium which the average cow contains in her body. If Forbes' results are quantitatively representative of what occurs under ordinary conditions, it would seem that the practice of feeding cows so that they produce from 15,000 to 30,000 pounds of milk in the year, as is now so frequently done with cows on test, must very often result in disaster to the animals subjected to it.

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[1] Paper read before the Production Section of the American Dairy Science Association, October 10, 1922, St. Paul, Minnesota.

There is reason to think, however, that Forbes' results, though very important and significant, are not quantitatively representative of what occurs under ordinary conditions. Some years ago the author in conjunction with others reviewed the metabolism experiments of the last fifty years in which calcium and phosphorus balances have been determined, and showed that the results of such experiments are such as to indicate that the conditions of balance experiments usually interfere with calcium assimilation (2). Very recently Hart and his collaborators have reported results which throw much more light on the subject (3). In Hart's experiments liberally milking cows were fed on rations of grain, corn silage, and alfalfa hay—practically the same rations that many of Forbes' cows got. The alfalfa hay used in these experiments was of two kinds. One lot had been cured in windrows with four days exposure to the sun; the other lot had been cured under caps. The cows which got the hay cured in windrows had much smaller negative calcium balances than Forbes cows—between 2 and 3 grams daily on the average. The cows which got the hay cured under caps had positive calcium balances.

It seems justifiable to sum up the evidence so far presented by saying that liberally milking cows, which are fed on large quantities of good alfalfa hay combined with concentrates high in phosphorus, and kept under favorable general conditions, are usually able to maintain themselves in calcium and phosphorus equilibrium. But it is highly probable that minor circumstances, which have hardly been noticed heretofore, such as changes in the quality of the hay and changes in general routine, are capable of producing negative balances.

It seems, therefore, that it is not quite easy to keep liberally milking stall-fed cows in calcium and phosphorus equilibrium, even when the rations are of the best. What occurs when some comparatively low calcium roughage such as timothy hay, oat straw, corn stover, or corn silage is substituted for the alfalfa? On this question there is no shadow of disagreement in the evidence from various sources.

Both Hart and Forbes have determined the calcium balances in liberally milking cows which received timothy hay or other roughage low in calcium. In all cases the calcium balances were markedly negative, the figures indicating that the cows were losing about 20 grams of calcium daily. In view of the possibility that the conditions of balance experiments may interfere with calcium assimilation, experiments are now being carried out at this station in which cows under ordinary farm conditions are being fed a high protein grain mixture combined either with timothy hay alone or with timothy hay and corn silage. The milk yield of these cows is being compared with others fed either on the same rations with calcium carbonate added; or on rations with the same protein content and otherwise as nearly as possible similar, but with alfalfa hay substituted for the timothy. These experiments are still far from complete, but the results so far agree in showing that the milk yield is always sooner or later markedly reduced by the rations with the low calcium roughage, and that a considerable part of this reduction at least, is caused by the calcium deficiency.

There is every reason to believe, therefore, that liberally milking stall-fed cows can be kept in calcium equilibrium only by feeding large quantities of roughage high in calcium, such as alfalfa hay. It need hardly be said that this practice is by no means universally followed, and there is no doubt that calcium deficiencies play an important practical part in the feeding of dairy cows as practiced in many parts of the country.

II

The question of the circumstances under which dairy cows are likely to be fed rations deficient in calcium or phosphorus has already been partially answered. But there are a number of important points still to be taken up.

The question of the effect of pasture on calcium and phosphorus assimilation has so far not been touched. In 1911 Fingerling reported results which showed that phosphorus was better absorbed by farm animals from fresh green roughage than from the same material after it had been dried and converted into hay (4). More recently Hart has shown that the same thing holds true for calcium both in the case of the oat plant and in that of the alfalfa plant (5). Fingerling suggested that the phosphorus compounds might be encrusted in the dried hay so that the digestive juices of the animals to which they were fed could not get at them. But, since his results were published, much work has appeared which indicates that the assimilation of calcium and phosphorus is influenced by vitamines. The vitamines in question may exert their influence even though they are fed as a part of one of the dietary constituents; and the calcium and phosphorus compounds, as another. Hart inclines to the view that fresh green plant tissue contains a vitamine which is favorable to calcium assimilation.

The evidence reviewed in section I, therefore, must be taken as applying only to animals which are fed exclusively on dried materials and corn silage. Dairy cows on pasture can maintain calcium equilibrium on a smaller absolute calcium intake than those on dried materials with or without corn silage. But the details of this subject remain almost wholly to be worked out. It will be necessary in the future to gather further evidence on the question whether the hypothetical vitamine in green plant tissue can be separated from the calcium and phosphorus compounds thereof and still retain its potency, whether it is contained in equal amounts in various species of plants, whether it is so potent that we may safely neglect the actual calcium and phosphorus content of the rations in the case of cows on pasture, how it may best be conserved in the curing of hay, etc., etc. These and similar questions seem to the author to call as urgently for solution as any others in the field at present; not only for the sake of the dairy industry, but also for that of the science of nutrition in general.

There are two other subjects which come properly in this section, on which our present information is very scanty, but which cannot be passed over without mention; namely the relation of calcium deficiency in the ration to the quantity of the milk yield, and the question whether, under practical circumstances, it is common for rations to be fed in which the chief deficiency is that of phosphorus.

Forbes has reported the results of determining calcium and phosphorus balances in the case of cows that were dry or giving only small amounts of milk. Both calcium and phosphorus balances were usually positive. The cows used in these experiments, however, received alfalfa hay. The results of feeding timothy hay to cows giving small amounts of milk have been observed to some extent at this station. The observations are not sufficient to justify any very positive statements. When cows giving small amounts of milk are changed from alfalfa to timothy hay, the yield does not fall off so soon or so markedly as when this change is made at a higher level; and some of the cows on timothy hay have continued to give a small amount of milk (in the neighborhood of five pounds daily) for many months consecutively. These cows, however, were consuming rations which contained much more protein and total nutrients than they required according to any of the feeding standards. It is doubtful whether the results should be considered anything more than examples of the fact that cows giving small amounts of milk can eat much more food than they require, and, in that way, compensate for the partial deficiency of some particular element of the food. It is perhaps not too strong a statement that it is always bad practice not to include liberal quantities of legume hay in the rations of dairy cows which are receiving only dry feeds and silage.

The cases where a deficiency of phosphorus in the rations of dairy cows plays an important practical part are probably much less common than in the case of calcium. The only rich source of calcium for these animals is legume hay, and it is easy to make up a ration without legume hay, but which nevertheless contains plenty of protein and total nutrients to provide for the most liberal milk yield. But phosphorus is plentifully contained in most of the high protein concentrates as well as in wheat bran, and most rations which contain enough protein and total nutrients to provide for a liberal milk yield, contain large quantities of phosphorus also. In her dry period, however, a cow can easily eat enough roughage to cover her requirements, and, under these circumstances, she may be getting a ration which is rather low in phosphorus. This station recently published a bulletin in which it was shown that the milk yield of cows which had been subjected for some years to the station routine could usually be improved by adding sodium phosphate to the ration given in the dry period.

The favorable effects of feeding phosphate in the experiments under consideration, however, were due to the cows having received deficient rations in their previous lactation periods. The results cannot, therefore, be regarded as proof that animals which should begin their dry periods in an ideal state of nutrition would suffer from a shortage of phosphorus during that period, even though they were fed chiefly on roughage with a low phosphorus content.

III

The question how calcium and phosphorus deficiencies in the rations of dairy cows are to be avoided has been answered nearly as far as it can be answered in the two preceding sections. The evidence now on hand indicates that the calcium question is much the more urgent of the two; that liberally milking cows probably always suffer from a calcium deficiency when they are fed on dry rations with or without silage and without a liberal admixture of alfalfa or other legume hay; but that they can be kept in calcium equilibrium if enough alfalfa hay of the right quality is provided. The evidence also indicates that the danger of a calcium deficiency is less acute when the cows are on pasture. In regard to the question of improving dairy rations which are low in their natural calcium content by the addition of a salt of this element, the evidence indicates that the improvement so obtained is very limited. The practice is not to be recommended for the present, except to help the dairy farmer out of a temporary dilemma.

What ought to be done by the practical dairy farmer in the light of present knowledge is perfectly clear. In feeding his cows he should follow the example of the engineer who has to build a bridge out of materials that may be faulty, and build somewhat stronger than the calculations call for. He should not attempt or hope for large yields of milk through the winter unless he has alfalfa or other legume hay at command. If he has alfalfa, it will probably pay him to feed a pound of it for every three or four pounds of milk that he obtains. And it will probably pay him also to see that each of his cows has a dry period of two months and that during that period she receives twice the maintenance ration in protein and total nutrients.

But most of all it will be worth while for him to realize how small and dim is the present light of knowledge in the vast field of ignorance of nutritional questions. In attempting to give practical advice, it is impossible at present to step out boldly in any direction. It is commonly thought that other legume hays can be substituted for alfalfa as a source of calcium, but there are no satisfactory experiments on the subject. The commonly received opinion is largely guess work. And the enormously important question of the calcium requirement for cows on different kinds of pasture has hardly been touched. The practical dairyman should realize that these questions and other similar ones can be answered by further work on the subject, and he should encourage attempts to answer them as far as he can.

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STUDIES IN THE GROWTH AND NUTRITION OF DAIRY CALVES

V. MILK AS THE SOLE RATION FOR CALVES

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From time immemorial milk has been regarded as the feed best adapted to the complete nourishing of mammalia. It is the sole ration of all mammals during the earlier part of their post-natal development and is also recognized as an excellent staple in the diet of the adult human, especially in the case of invalids. On the farm it is used extensively in the feeding of young animals, and in the case of the hog it is fed in large quantities to more mature individuals.

Within the last decade much investigational work has been done concerning the nutritive value of milk and other feed stuffs. The major portion of this work has been conducted with laboratory animals and no attention has been paid to some of the factors which determine to a large extent the value of milk to certain types of livestock. The object of the work reported here was to determine the value of milk as the sole ration for calves.

RÉSUMÉ OF PREVIOUS WORK

The nutrients recognized as essential to the welfare of the animal organisms are carbohydrates, fats, proteins, ash, water and the food accessories or vitamines. The proximate composition of milk, showing the average amounts of the most abundant constituents present, is given in the first tabulation.

The proteins, fats and carbohydrates are present in the proportions that are recognized as being suited for the growth of young animals and the ash constituents are also abundant.

Within recent years it has been shown that all proteins are not of equal value for nutritional purposes as the nutritive value of a protein is determined by its amino-acid constitution. Some proteins are inadequate due to the fact that they do not contain all the amino-acids necessary for the life, growth and normal physiological development of animals. However, it has been shown by McCollum (26) that the milk proteins are adequate, that is, they will in the presence of a sufficiency of non-protein and inorganic nutrients, support life, promote growth, and foster all normal physiological functions.

The ash is another feed constituent which, though present in sufficient quantities, may not be qualitatively suited to the requirements of the animal, but it has been proved by Osborne and Mendel (28) that the ash of milk satisfactorily meets the demands of the young growing animal, providing in the proper proportions all of the inorganic constituents needed for the proper functioning of the animal body.

TABLE 29

Average composition of milk (31)

CONSTITUENT	PER CENT
Water	87.17
Fat	3.69
Casein	3.02
Albumen	0.53
Sugar	4.88
Ash	0.71

Another factor recognized as limiting the nutritive value of feeds is the presence or absence of the vitamines, fat-soluble A, water-soluble B and water-soluble C. The fact that fat-soluble A is present in abundance in milk has been proved many times as can be seen from the compilations of Blunt and Wang (16), (17). Milk is not too rich in water-soluble B, according to Osborne, Mendel, Ferry and Wakeman (29) but there should have been sufficient of it supplied, according to McCollum, Simmonds and Pitz (27), to satisfy the experimental animals. It is perhaps true, however, that insufficient amounts of water-soluble C were present according to Chick, Hume, Skelton and Smith (18), (19).

Thus far only work conducted with laboratory animals has been mentioned as this leads up to and helps to explain some of the results obtained on using rations from limited sources with farm livestock. In addition to its chemical character a ration must be of the proper physical nature before it supplies the needs of farm livestock.

In only a few instances have records been obtained of ruminants being fed for any considerable time on rations consisting entirely of feeds of the same physical character, but Sanborn (30) reports that in the case of both sheep and cattle fed on grain the stomachs weighed less than normal and this was most noticeable in the case of the rumen—the stomach compartment especially adapted for the handling of bulky material. Davenport (20) found that calves could not be raised on a ration consisting of milk alone or grain alone and he also noticed that as a rule no digestive disturbances accompanied such a ration.

Work of McCollum, reported by Henry (21), apparently showed that a sow pig was able to reach maturity and reproduce normally when fed milk alone.

EXPERIMENTAL WORK

In the work reported here, two bull calves were used and they were fed on milk alone from birth until the time of their death. The animals are described in table 30.

Both calves were allowed to remain with their dams for a few days after birth and were then put on a whole milk ration. The amount of milk fed was limited to what the calves seemed able to handle satisfactorily and though they might possibly have become accustomed to larger quantities, it was deemed advisable to keep their consumption of milk comparable to that of other animals of similar weight in the herd and thus prevent digestive troubles as far as possible.

No roughage, grain or water was offered to either of the calves, and at first no salt was given, but from the time calf 355 was 70 days old, a salt roll was kept in front of him at all times and the same treatment was given calf 366 from the time he was 30 days old.

The calves were kept in a pen bedded at first with shavings and later with sand, as they showed a tendency to eat the shavings. Their feed consumption by 10-day periods is given in table 31.

TABLE 30

Animals used

	CALF NUMBER	
	355	366
Breeding	Grade Jersey	Grade Holstein
Date of birth	9–25–16	12–17–16
Birth weight, pounds	65	90

TABLE 31

Feed consumption by ten-day periods

PERIOD NUMBER	CALF 355		CALF 366	
	Milk	Salt	Milk	Salt
	pounds	*pounds*	*pounds*	*pounds*
1	36		90	
2	90		90	
3	90		90	
4	90		90	0.04
5	128		111	0.05
6	120		129	0.06
7	120		150	0.04
8	126	0.32	150	0.03
9	146	0.25	150	0.11
10	150	0.17	150	0.21
11	150	0.05	150	0.10
12	150	0.02	150	0.03
13	150	0.04	150	0.04
14	150	0.06	150	0.03
15	141	0.05	150	0.03
16	120	0.03	150	0.02
17	120	0.07	174	0.03
18	120	0.18	108	0.03
19	123	0.17		
20	142	0.02		
21	99	0.03		

In the first 10-day period calf 355 sucked for 6 days and no. 366 for 3 days. The last period for no. 355 contains only 8 days and that for no. 366 only 6 days, as no. 355 died when 208 days old, and no. 366, at the age of 176 days.

It will be noted that up until he was about 100 days old, no. 355 had an increasing capacity for milk, but from that time the appetite remained regular for a little over a month and then declined, though there was an increase in milk consumption for a week or so before death. In the case of no. 366, maximum capacity was reached earlier and remained constant until about the same length of time before death, when it again increased.

The animal, no. 355, that received no salt until 70 days old, showed an enormous appetite for salt during the first 30 days in which it was available. From this time on his salt consumption decreased and with the exception of a short time between the ages of 170 and 190 days it did not again reach a marked elevation during the experiment. Calf 366 received salt earlier in his life and did not at any time have such an excessive consumption, though between the ages of 80 to 110 days his consumption of salt was large.

There were no marked digestive disturbances, except in the case of calf 366, which was bloated for a few days before death, the bowels of the animals being usually laxative, though not noticeably so. The feces were rather foul smelling. The calves showed by their actions that their rations were not entirely complete. They ate to a slight extent the shavings that were at first used as bedding, gnawed the wood in the walls of the pen, and licked the hair from each other. These substances, however, were not consumed in amounts sufficient to cause very noticeable digestive derangements.

Records of the live weights and body measurements of the calves obtained every 30 days are given in table 32. The live weights given are the averages for three successive daily weighings. The body measurements taken were height at withers, depth of chest and width at hooks. For the sake of comparison, the measurements of the heifer calves in the herd fed normal rations are given. Difference in sex will not have much influence on these figures for comparative purposes owing to the sexual immaturity of the animals and also to the fact that calf 355 was castrated when 22 days old.

It can be seen that the experimental animals grew fairly well until they were two to three months of age, but from this time on they did not thrive. They continued to gain slowly in weight for another 30 days, after which their live weights decreased gradually until the time of death. The body measurements appeared to increase about normally until the time the live weight increase ceased to be rapid and from this time on the measurements changed only slightly—in fact they were almost constant. A greater increase in height than is shown by the figures probably did occur, but owing to the fact that the animals began to go down on their pasterns about the time the live weight ceased to increase, the true height could not be accurately measured.

TABLE 32

Live weights and body measurements

AGE	CALF 355				CALF 366				AVERAGE FOR 40 HEIFERS			
	Weight	Height	Depth	Width	Weight	Height	Depth	Width	Weight	Height	Depth	Width
days	*pounds*	*inches*	*inches*	*inches*	*pounds*	*inches*	*inches*	*inches*	*pounds*	*inches*	*inches*	*inches*
Birth	65				90				67			
30	76	29.9	12.6	7.1	103	28.0	14.3	7.5	90	28.7	11.4	6.7
60	107	31.1	13.0	7.5	139	30.3	14.3	7.9	120	30.7	12.8	7.5
90	132	32.3	13.8	7.9	165	32.7	14.7	8.7	163	32.9	14.2	8.5
120	145	33.9	15.0	8.3	174	35.0	15.7	8.7	211	34.8	15.4	9.4
150	144	35.0	15.4	8.3	172	35.4	15.7	9.1	262	36.4	16.7	10.2
180	137	34.6	15.0	8.3					314	38.4	17.9	11.2

The increases in live wieght and body measurements can be more easily appreciated when they are shown as percentages of the original figures, as in table 33. The increases in live weight from birth to the end of the last completed 30-day period in the case of experimental animals, and to the ages of five and six months in the case of the herd average, are expressed as percentages of the birth weights, while the body measurements are compared in the same way from the time the animals were 30 days of age.

During their lifetimes the experimental animals practically doubled their live weights, while during similar lengths of time calves normally fed attained weights more than four times as great as their birth weights. Similarly the increases in body measurements in the case of the calves fed milk alone were much less than normal, except in the case of the height of calf 366, which was normal. Of the increases in body measurement, the height was the most nearly normal, while width was farthest from it, and as a general rule the rates of growth in the body measurements showed less variation from normal than did the rate of gain in live weight.

In addition to the variations in weight and body measurements there were other abnormal symptoms which though very appreciable were not capable of being directly measured or determined. The animals became very much emaciated and quite unthrifty in appearance. Their coats were long and staring and the hair fell out freely. Patches of the body became practically devoid of hair and sores were also apparent. As has already been mentioned, the animals were down on their pasterns and could not stand up properly and they walked with a very stiff gait.

TABLE 33

Percentage increase in live weight and body measurements

CALF	AGE	WEIGHT	HEIGHT	DEPTH	WIDTH
	months	*per cent*	*per cent*	*per cent*	*per cent*
Experimental:					
No. 355	6	111	14	19	17
No. 366	5	91	27	11	21
Herd average	6	369	34	57	67
	5	291	27	47	52
Percentage of normal rate of increase:					
No. 355	6	30	41	33	25
No. 366	5	31	100	23	40

One very noticeable feature of the experiment was the occurrence of fits. These fits were first apparent when the animals were between three and four months of age and continued to occur at frequent but irregular intervals up until about three weeks before the animals died. These fits were all very similar and frequently started for no apparent reason and could almost always be induced by leading the animals around for a few minutes. The animal would fall down and bellow as if in pain; the jaws would stick open and the legs become rigid; the muscles became tense and hard: respiration slowed and in severe attacks entirely stopped. Where respiration did not stop the animals would recover in a few minutes, and where breathing ceased, artificial respiration had to be resorted to, to resuscitate the calf. The fits were practically identical with those of an epileptic nature.

Post-mortem examinations of both calves were made. The bones of no. 355 were very flexible as if insufficient ash were present; the leg bones could be bent comparatively easily, while the ribs had a very thin coating of hard material with a soft core. None of the bones were as rigid as would be expected in an animal of similar age. There was one atrophied kidney (perhaps congenital) with hypertrophy of the other. The mesenteric lymph glands were much enlarged and there was an apparent leucemia. The rumen was of normal size, but the walls were evidently atonic, due apparently to a development of lymphoid tissue. The omasum was smaller than would be expected, though the two remaining compartments of the stomach appeared to be normal. The contents of the rumen resembled thin cottage cheese mixed with hair.

The bones of calf 366 appeared to be in fairly good condition, though one or two of the ribs might previously have been broken and healed. The mesenteric lymph glands were enlarged and both kidneys were in bad condition with cysts. All the stomach compartments were of about normal size, but there were streaks of dark brown or black pigment on the inner wall of the abomasum. The contents of the rumen were similar to those in the case of calf 355.

DISCUSSION OF RESULTS

Whole milk, though apparently giving good results until the animals are about three months old, very probably cannot be relied on as the sole ration for calves of greater age. Its inability to properly nourish older calves may be due to one or more of a number of factors.

Cattle and other ruminants begin to consume roughages at an early age and the lack of roughage may consequently give an explanation of the results obtained in this work. In addition the quantity and quality of the nutrients supplied may be of importance as well as the supply of nutrients.

In table 34 are given the requirements of young growing dairy calves according to the modified Wolff-Lehmann feeding standard as outlined by Henry and Morrison (22).

From the data supplied the nutrients required by, and actually supplied to the experimental calves have been calculated. In this table the animals have been taken together rather than individually and the milk consumption is taken for all 30-day periods which were completed. It was assumed that the daily milk consumption of the calves while sucking was the same as in the succeeding days of the first 10-day period.

TABLE 34

Nutrients required daily by young growing calves per 1000 pounds live weight

WEIGHT	DRY MATTER	DIGESTIBLE NUTRIENTS	
		Crude protein	Total
pounds	*pounds*	*pounds*	*pounds*
150	23	4.0	22.0
300	24	3.0	18.3
500	27	2.0	15.8

The actual surplus or deficit of nutrients supplied will be more valuable for comparative purposes and this is obtained by summarizing the data just presented.

Considerable variations are noticeable in the amounts of the nutrients supplied but the importance of these variations is perhaps best demonstrated when the oversupply or deficiency is expressed as a percentage of the actual amount required by the calves.

It is evident that from the beginning the calves were not receiving sufficient dry matter in their rations. The average amount of dry matter supplied in the first 30 days was 33 per cent below that required by the animals and this deficiency continued to become greater until in the fifth 30-day period it amounted to 66 per cent.

During the first two 30-day periods the calves received sufficient digestible crude protein and total digestible nutrients but from then on these constituents were deficient in the rations but never to such a great extent as was the dry matter. The calves were being given all the milk they could handle but were supplied with no bulky feed to supply them with the extra dry matter needed. The lack of this dry matter, which would have provided additional bulk, impaired the digestive powers of the animals and rendered them unable to handle sufficient milk to provide all the digestible nutrients they required. This in turn led to poor growth and development.

The digestive tract of a ruminant is large and capacious and before digestion can be normal, bulky feeds must be present to distend the digestive organs, stimulate peristalsis, separate the particles of more concentrated feeds and so allow of their being properly mixed with and acted on by the digestive fluids. Milk, being highly digestible and free from fibrous material, is not a "bulky" feed, though its nutrients are present in a rather large volume of water, and so it cannot, when fed alone, induce the digestive system of older ruminants to function properly, though it is quite efficient with young calves, as in their case the rumen is relatively smaller in comparison with the rest of the digestive tract than it becomes ultimately.

Where digestion is retarded or hindered, as would occur when the digestive system became atonic due to the absence of roughage, the materials not completely acted on by the digestive juices would remain in the alimentary canal and undergo putrefactive changes. The products of such putrefaction are toxic and when absorbed from the alimentary canal can produce autointoxication, with symptoms similar to those found with the experimental animals in this case.

Another fact worthy of note is that these calves were at times, when averaging about 150 pounds in live weight, consuming over half as much salt per day as would a 1000-pound animal. It has been found at this station that normally fed calves of similar weight will consume about 0.01 pounds of salt per day, while the experimental animals consumed as much as 0.03 pounds per day.

This excessive salt consumption may have been an attempt to correct digestive disturbances, or it may have been caused by other physiological demands, or it may simply have been due to to the calves forming a pernicious habit.

That sodium chloride can produce tetanic convulsions such as were evident in the case of the experimental calves has been shown on several occasions. Loeb (23) demonstrated the contractions and final tetanus of muscles in contact with certain salt solutions and he later (24) showed that solutions of common salt could cause rhythmical twitchings and an increase in the irritability of muscles and nerves. This is due to an increase in the concentration of sodium ions and can be counteracted by the addition of calcium salts. It has also been pointed out by MacCallum (25) that intravenous injections of solutions of sodium chloride increase peristalsis. There is a possibility, therefore, that the fits to which the experimental calves were subject may have been due in some way to excessive salt consumption.

TABLE 35

Nutrients required by and supplied to calves

AGE	AVERAGE LIVE WEIGHT	MILK SUPPLIED	NUTRIENTS SUPPLIED			NUTRIENTS REQUIRED		
			Dry matter	Digestible		Dry matter	Digestible	
				Crude protein	Total		Crude protein	Total
days	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
1–30	168	579	79	19	104	116	19	109
31–60	213	668	91	22	120	150	23	133
61–90	272	842	115	28	151	195	26	149
91–120	309	900	122	30	161	223	27	169
121–150	318	873	119	29	166	228	28	173

It has been pointed out previously that the vitamines, water-soluble B and water-soluble C may not be present in milk in sufficient amounts for the continued well being of the experimental animals. Further work is needed to determine whether each or all of these factors mentioned here were responsible for the unthriftiness, mal-nutrution and ultimate death of the animals used in this work.

TABLE 36

Excess of nutrients supplied to calves

AGE	DRY MATTER	DIGESTIBLE NUTRIENTS	
		Crude protein	Total
days	*pounds*	*pounds*	*pounds*
1–30	−37	0	5
31–60	−59	1	13
61–90	−80	−2	−2
91–120	−101	−3	−8
121–150	−147	−1	−7

TABLE 37

Excess of nutrients supplied to calves expressed as a percentage of the requirements

AGE	DRY MATTER	DIGESTIBLE NUTRIENTS	
		Crude protein	Total
days	*per cent*	*per cent*	*per cent*
1–30	−33	0	5
31–60	−39	4	10
61–90	−41	−8	−1
91–120	−45	−11	−5
121–150	−66	−1	−4

SUMMARY

From the evidence obtained in this work the following factors may be looked on as possible causes of milk being unable to supply all the nutritional wants of calves after they are a few weeks old.

1. The lack of bulk may arrest the development of the alimentary tract and prevent the proper digestion of the nutrients supplied by the milk.

2. Excessive consumption of salt, due to depraved appetite, or to an attempt on the part of the calves to correct nutritive disturbances, may have led to some of the disturbances noted.

3. The vitamines, water-soluble B and water-soluble C, may have been present in insufficient amounts and this may have induced the death of the calves.

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ANNUAL MEETING OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

GENERAL SESSION

The seventeenth annual meeting of the American Dairy Science Association was held October 10, 1922, at the University Farm, St. Paul, Minn. President Eckles in his informal opening address urged greater support of the JOURNAL OF DAIRY SCIENCE, which is being carried by the publishing company at an annual loss, and the necessity of the Association securing an affiliation with the National Research Council. C. C. Thomas of Williams & Wilkins Company, publishers, emphasized the need of stronger support for the JOURNAL.

COMMITTEE REPORTS

The report of the Joint Committee of the International Milk Dealers' Association and Agricultural College representatives was given by A. A. Borland. (This report is published in detail on page 75.)

Report of Program Committee for World's Dairy Congress, L. A. Rogers, chairman.

Report of Editorial Board, J. H. Frandsen. (Report in detail on page 77.)

Dr. Eckles was made the fourth member of the committee on affiliation with the National Research Council, upon motion made by Dr. Breed, chairman of the committee.

The report of the Membership Committee was given by J. A. Gamble.

A. A. Borland read a paper on "Extension Activities and Their Relation to the College and Experiment Station." Professor O. E. Reed led the discussion that followed.

Officers for 1923, elected on the December ballot, are: President, A. A. Borland, State College, Pa.; vice-president, O. E. Reed, East Lansing, Michigan.

ANNUAL BANQUET

Nearly 300 were present at the annual banquet of the American Dairy Science Association, held at the Dairy Exposition ground at St. Paul. A. A. Borland of Pennsylvania, vice-president of the Association, was toast-master. R. A. Pearson, president of Iowa State College, was the principal speaker.

STUDENTS' NATIONAL CONTEST IN JUDGING DAIRY CATTLE

The results of the Fourteenth Students' National Contest in Judging Dairy Cattle, held at the National Dairy Show on the Minnesota State Fair Grounds, October 9, 1922, were announced at the banquet by W. W. Swett, superintendent of the contest. North Dakota won first place for the best teamwork in judging all breeds; Oregon, second; Iowa, third. The North Dakota Agricultural College, therefore, was awarded the National Dairy Association and the Hoard's Dairyman cups, both of which were new and given to replace the two sweepstakes cups permanently awarded to Kansas State Agricultural College in 1921 on the basis of that institution winning them three successive years. Oregon Agricultural College, second, was given the Wyandotte cup offered by the J. B. Ford Company.

Teams from twenty colleges or universities, representing the following states, participated: Illinois, Indiana, Iowa, Kansas, Kentucky, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Dakota, Ohio, Oregon, Tennessee, Texas, West Virginia, and Wisconsin.

The National Dairy Association's medals, sweepstakes, for the best individual work in judging all breeds were awarded the following men: Oliver K. Beals, Oregon, gold; Harper J. Brush, North Dakota, silver; A. H. Jessup, Indiana, bronze.

The official judges on placing were W. S. Moscrip, Minnesota, for Holstein classes; J. A. McLean, Chicago, for Jersey classes; J. B. Robertson, Maryland, for Guernsey classes; and L. S. Gillette, Iowa, for Ayrshire classes.

The Students' National Contest in Judging Dairy Cattle has been held regularly for fourteen years and has been sponsored not only by the American Dairy Science Association but by the National Dairy Association and the various breed organizations. It is believed that the work has been instrumental in unifying the instruction in dairy cattle judging in the colleges throughout the United States. The contest was under the supervision of the Dairy Division, Bureau of Animal Industry, United States Department of Agriculture.

(Signed) J. B. FITCH.

PROCEEDINGS OF SECTION I, DAIRY PRODUCTION

Meeting was called to order by Vice-Chairman A. C. Ragsdale in the absence of Chairman Regan.

Report of committee on methods of conducting students' judging contests was given by W. W. Swett, chairman. (This report is given in full on page 79.) The section went on record as discouraging any institution from taking an excessive amount of time from the college in preparation for contests. The section also recommended to the committee in charge that it arrange to have an associate college judge work with the breed judge next year.

The report of the committee on dairy cattle score card, given by J. R. Rice, was approved and the score card accepted and adopted as presented by the committee. (This report together with score card is given in full on page 80.)

The suggestion of Mr. Hayden that more scientific papers be presented and less routine matter discussed at annual meetings was discussed at some length.

Two papers were presented (printed elsewhere in this issue): "The Relation of Pigmentations to Fat Production in Dairy Cattle," by Dr. Palmer of Minnesota; "Mineral Requirement of Dairy Cattle," by Dr. Meigs of the United States Department of Agriculture, read by Mr. Davis.

Officers elected were: Chairman, O. E. Reed, Michigan; vice-chairman, W. W. Yapp, Illinois; secretary, A. P. Rayburn, Minnesota.

(Signed) H. O. HENDERSON,
Temporary Secretary.

PROCEEDINGS OF SECTION II, DAIRY MANUFACTURES

Session was called to order by Dr. L. A. Rogers, chairman, in Dairy Hall, University Farm, Minnesota. Forty-five were present at the call to order.

Report of the committee on score cards and standards

The report of the committee on score cards and legal standards was given by J. H. Frandsen, chairman. It included the following suggestions:

1. That the score card for whole milk be changed as follows: The points allowed for acidity to be eliminated and added to the points allowed for flavor.
2. That the score card for condensed and evaporated milk be changed by having the points allowed for body and texture and bacterial count increased, and the points allowed for fat and flavor decreased.

The section passed a motion that uniform rules should be used in all contests in which students take part this year.

On motion the duties of a committee on bacterial methods were added to those of the committee on official methods for testing milk and cream.

The new issue of methods of the American Bacteriological Society, including chemical methods for examining dairy products, and the report of the committee on standard methods were approved. The committee on standard methods, of which Professor Hunziker is chairman, will be continued and will take up the matter of differences of opinion between the American Dairy Science Association's standard methods and those published by the United States Bureau of Standards.

After considerable discussion Professor Stocking's motion that the committee on standard methods should include in its work the determination of a standard method for milk solids not fat determination was carried.

The utilization of by-products was the general topic of the symposium which formed the program. The following papers (published in this issue or to be published later in THE JOURNAL of DAIRY SCIENCE) were given:

"Utilization of Skim Milk by the Manufacture of Milk Powder," C. E. Grey, president of California Central Creameries.

"Utilization of Buttermilk for Hog and Poultry Feeding," O. F. Hunziker, manager of manufacturing department of Blue Valley Creamery Company.

"Utilization of Whey," A. C. Weimer, dairy manufacturing specialist, United States Department of Agriculture.

The following officers were chosen for 1923: Chairman, H. A. Ruehe, Illinois; secretary, J. R. Keithley, Minnesota.

(Signed) H. A. RUEHE,
Secretary.

PROCEEDINGS OF SECTION III, DAIRY EXTENSION

The Dairy Extension Section met in Dairy Hall, University Farm, St. Paul, Minnesota, 1:30 p.m., October 10, 1922.

Meeting was called to order by Chairman E. M. Harmon of the University of Missouri, Columbia, Missouri.

C. R. Gearhart, chairman of the committee on standardization of Cow Testing Association work, Manhattan, Kansas, gave a detailed outline of the work done by the committee in standardizing cow testing work. Mr. Gearhart stated that four state institutions have given credit toward graduation where a tester took up Cow Testing Association work. Two states have adopted the Register of Production plan of recording cows that have made more than 365 pounds of butterfat. The committee recommended a shorter constitution and by-laws furnished by the United States Dairy Division. When voted upon by the assemblage at this meeting, it was unanimously recommended that the new constitution and by-laws be adopted, and there were several changes made in the contract for membership agreement. It was finally agreed upon that two copies should be made of each contract which the members are signing. Twelve members voted for the check system to be adopted, while eight members voted against it. The committee's recommendations on rules and changes in the herd record book, and the details on recommendations for the new bulletin by Mr. J. C. McDowell, of the Dairy Division, were adopted.

A report was made by Mr. F. A. Buchanan, chairman of the Calf Club Association Committee. The states most active in calf club work are New Jersey, Nebraska, West Virginia and Missouri.

Mr. O. E. Reed of Lansing, Michigan, gave a splendid talk on the work that has been done along dairy improvement lines in the state of Michigan. He urged holding more of our group and community meetings directly on the farm and not in a town hall. Mr. Reed stated that invariably more of the real thoughts which the farmer should get were driven home more strongly on the farm than would be in a meeting held in a city.

Mr. L. W. Morley, chairman of dairy products committee, State College of Pennsylvania, gave a brief talk on the handling of butter, cheese and cream in the various states throughout the United States.

Mr. C. S. Rhodes of Urbana, Illinois, gave a report on Coordinating Extension Work with that of the resident departments, the state leaders and the county agents.

Miss Jessie Hoover, chairman of committee on milk campaigns, emphasized the marked increase in the consumption of milk and dairy products after a milk campaign had been successfully conducted. She stated that in Madison, Wisconsin, there was a 35 per cent increased consumption in milk alone in the course of one year.

A. C. Baltzer, chairman of bull association committee, gave an outline on the successful organizing and supervising of bull associations.

M. H. Keeney, New Brunswick, New Jersey, spoke on "How Can We Make of the Individual Cow Testing Association Member a Demonstration for His Whole Community."

A resolution was sent to Mr. George, thanking him for his services as secretary.

The following officers were elected for 1923: Chairman, E. M. Harmon, Columbia, Mo.; vice-chairman, M. N. Lauritson, Lincoln, Nebr.; secretary-treasurer, A. J. Cramer, Madison, Wis.

PROCEEDINGS OF SECTION IV, OFFICIAL TESTING

The following is a summary of the proceedings of the official Cow Testing Section of the American Dairy Science Association, which met October 11, 1922, at St. Paul. The session was called to order by Chairman H. P. Davis. Roy T. Harris was secretary.

The data concerning the importance of the preliminary milking was reviewed and summarized by Professor Borland of Pennsylvania. The work at Nebraska, Kansas, New Jersey and Pennsylvania contributed to the following conclusions of the conference, viz.: Leaving milk in the udder may result in (a) a higher milk yield during the two-day period; (b) a higher fat yield during the two-day period; (c) a higher test during the two-day period; and (d) would help to conceal padding of milk sheets. These conclusions were concurred in by officers of the American Jersey Cattle Club and the Holstein-Friesian Association and by Jersey breeders present. It was also pointed out that the preliminary milking fixes the hour of the first milking so that padding of milk records cannot be concealed by extending the milking period. It was voted unanimously that the preliminary milking should be retained if a satisfactory substitute could not be found.

Professor Colman's sub-committee report and the report of Mr. Baker of the American Jersey Cattle Club were then considered wherein the first, second, third and fourth milkings were compared with the corresponding milkings. It was agreed that the variation was so great that in the present light no standard could be set which would surely indicate deliberate attempt at fraud.

The preliminary milking should therefore be enforced with all breeds until amended by the American Dairy Science Association. The uniform blanks which are being prepared and which should be in use by February 1 provide a space in which to enter the weight and test of the preliminary milking. This will not be included in the totals and averages, but will serve for comparison with the other tests and as a check on the supervisor. All agreed that this was desirable and Mr. Gardner of the Holstein-Friesian

Association especially emphasized this point. The Jersey, Guernsey, Ayrshire, Holstein and Shorthorn Associations have adopted this uniform blank. No others have as yet ordered a supply.

The American Jersey Cattle Club representatives then asked for an opinion of a one-day test compared to the two-day test. This had been considered by the committee through a suggestion of Professor Erf of Ohio, who believes that a test period should be of short duration to prevent manipulation of the cow, and was objected to on the grounds that new steps should be taken only when sufficient information is available to justify changes in methods. The committee desires information on this subject and believes it to be a problem worthy of study by as many states as possible within the next year.

The Committee recommended the amending of Rule 9 by omitting "by pouring from one pail to another at least twice," which was adopted. In the same rule an amendment to read "in warm weather samples kept over night should be kept in a cool place or preservatives should be added to each sample" was also adopted.

The matter of collecting by Breed Association has thus far been blocked by three Associations which feel that they are not in a position to undertake it. Some breed officials do not approve of the plan in principle. The committee hopes through Mr. Munn of the American Jersey Cattle Club, who has been instructed by his directors, to get a uniform guarantee plan in operation in all of the Associations at once.

In all, the committee and sub-committee reports for the year and the proceedings of the St. Paul meeting, cover sixty-one type-written pages. Some of the general recommendations follow:

1. That each state accept the rules and plans as finally adopted at the conference and put the plan into operation January 1, 1923, or earlier. (Due to the delay, February 1 would now be a reasonable date.) There may be some real objections to the present rules and some will have to give up a few "pet ideas," but we believe the rules adopted by the Official Testing Section should prevail in all states.

2. That any modification or addition to these rules should be duly presented to this committee which in turn will present them to the general body at the annual meeting and that these rules should always be regarded as a minimum standard in conducting tests. It is only by this plan that we can keep the work on a high plane, command the unwavering support of the Breed Associations in this work, and develop uniformity of procedure among the Associations themselves.

3. That the rules as adopted by the American Dairy Science Association should be placed in the hands of the supervisors and breeders in each state by the superintendent of Advanced Registry of each state.

4. That the state superintendents and their assistants should show due consideration for the breed association officers and endeavor neither to write nor speak to breeders in such manner as to bring embarrassment to the officers, except where the matter has been given due consideration.

5. That superintendents conducting retests have the authority to go beyond the rules if deemed necessary to safeguard the records.

Mr. Baker of the American Jersey Cattle Club suggested the desirability of a uniform plan where state superintendents make monthly progress reports of high yielding cows. A number of these reports reach his office, each of which has its own pattern. The appended blanks are offered by the committee for presenting the principal data in making these reports.

The following were elected officers of the section for 1923: Chairman, Roy T. Harris, Wisconsin; secretary, G. C. White, Connecticut.

REPORTS OF COMMITTEES

Recommendations of a joint conference of the committee on agricultural colleges of the International Milk Dealers Association and representatives of the dairy departments of the agricultural colleges on the problems of training men for milk plant work

Held at the Curtis Hotel, Minneapolis, Minn., October 8, 1922.

It is the desire of the Agricultural Colleges to be of greatest service to the Market Milk Industry. It is believed that this service lies along two general lines,—that of solving industrial problems and that of training men.

We also feel that more attention should be given by the Agricultural Colleges to the problems of the milk dealers. In accomplishing these ends the Agricultural Colleges desire the closest coöperation with the milk dealers so that the problems of both may be mutually understood.

The present suggestions are concerned with the development of men prepared to grow into the broader responsibilities of the business rather than the training of routine workers.

The aim of this training is to lay a foundation on a thorough knowledge of the fundamental sciences together with training in their application to the Market Milk Industry.

Such men should rapidly grasp the details of commercial problems and operations as they occur in the milk plants.

It seems to us that it is the duty of the milk plants to develop these technically trained young men into real milk plant experts.

The course of study which will best fit men for responsible positions in milk plants should include a thorough training in the fundamental sciences coupled with as much applied work as the student's time will permit.

The fundamental sciences should include Chemistry, Physics, and Bacteriology, each to be followed by courses making clear their application to the Market Milk Industry.

The applied courses should include work in Market Milk, Butter, Cheese (including fancy cheeses), Ice Cream, Condensed Milk, Powdered Milk, Dairy By-Products and Dairy Machinery.

The instructions in these courses should be directed toward showing the application of science to these subjects as well as developing manual skill.

Special attention should be given to the subject of economics. The work in this field should likewise include training in both the fundamentals and their application to dairy problems.

During the Senior year there should be a course in Milk Plant Management which should bring together and coördinate the previous teaching in the scientific and applied courses.

We feel that the milk companies can render valuable assistance in the better development of good men by making it possible for students to get experience in milk plants during the summer months.

Report of Editorial Board. J. H. Frandsen, Editor

Field of the Journal of Dairy Science. A score of trade journals in the field now, covering practically every phase of dairy activities from milk production to the making of ice cream, furnish dairy information in popular language particularly adapted to the producer and manufacturer of the many and varied dairy products.

However, until the appearance of the JOURNAL OF DAIRY SCIENCE there was no medium open for the publication of technical and valuable scientific dairy papers except in condensed or in popular version.

It was to provide a vehicle for disseminating such scientific dairy data, as well as to provide a permanent record of such material easily available to students and investigators, that this JOURNAL was created. In this particular field the JOURNAL has no competitors and has been welcomed by teachers, investigators, law enforcement officials, producers, progressive manufacturers and editors of trade publications.

Since by common consent it has this splendid field all its own, the editorial board feels that it would be a serious mistake to attempt to cover any of the work now so well taken care of by the Trade Journals. Since the JOURNAL is the medium for the publication of essential scientific data, there is obviously every reason why it should not give space to long editorials—mere opinions of the editor or editorial board. As a matter of fact the editorial page of even our daily newspapers is fast losing its former place of influence, and one of our leading journalists even predicts that in the near future this page will be entirely eliminated from our modern newspaper.

For these reasons the editorial board feels that the JOURNAL OF DAIRY SCIENCE can render the best service to the Dairy Industry of America and is making no mistake by continuing its present policy of being preeminently a scientific publication. However, the

JOURNAL is yet in its childhood, and most of its development lies in the future. With a view to assist the prospective contributor the editorial board has deemed it desirable to issue the following statement of policy.

Statement of policy adopted by editors of Journal of Dairy Science, October, 1922. Since at the present time a larger number of manuscripts are submitted for publication in the JOURNAL OF DAIRY SCIENCE than the limited available space in the JOURNAL will accommodate, the editors have been obliged to adopt certain limitations in accepting papers for publication. Henceforth, it will be the policy of the editors:

1. To accept only in rare instances papers containing more than twenty (20) pages of material, double-spaced, standard letter-size, including tables, cuts and drawings.
2. To accept only such papers as have a direct bearing on dairy problems.
3. To exercise a more rigid culling of papers for publication from the standpoint of both subject matter and quality.
4. As a rule manuscripts that have appeared in other publications will not be used in the JOURNAL OF DAIRY SCIENCE.

Suggestions to authors. Contributors are urged to coöperate with the editors by observing the following rules:

1. Make papers as brief as possible, without sacrificing completeness or accuracy.
2. Omit unnecessary plates and diagrams.
3. Do not present the same data by both tables and graphs. Use only the one that will present the results more effectively.
4. In case of duplicate determinations in tables, give only averages.
5. Avoid long historical reviews. Include only such references as have a direct bearing on the problem under study.
6. Submit only original type-written copy. Retain a duplicate copy.

Report of the committee on methods of conducting student judging contests. W. W. Swett, chairman

The committee on methods of conducting the Students' National Contest in Judging Dairy Cattle met at the headquarters of the National Dairy Show in Chicago at 10:00 a.m., April 14, 1922. Members present were: W. W. Swett, chairman, S. C. Thompson, H. H. Kildee, E. L. Anthony, and H. H. Wing. J. B. Fitch and W. M. Regan were unable to be present. Mr. Anderson from the office of the National Dairy Show, and J. C. McDowell of the Dairy Division were present to assist with some of the details of the work.

Mr. McDowell served as secretary on the request of Mr. Swett.

Suggestions from forty-five agricultural colleges regarding changes in contest rules were read.

Mr. Kildee made a motion, carried unanimously, to continue the one-judge system of last year.

On request of Mr. Thompson it was decided that the actual expense of the judges selected should, if possible, be paid out of Dairy Show funds.

It was moved by Mr. Kildee and seconded by Mr. Anthony that the per cent system of grading students on placings and reasons be used instead of the ranking system this year. The motion was unanimously adopted.

On motion of Professor Kildee, unanimously adopted, the number of student groups will be reduced from four to three. The purpose of the change is to facilitate student judging work in the ring.

Professor Wing made a motion that no reasons should be required on bulls and that students should write reasons on cows only. It was carried unanimously.

It was moved by Mr. Wing, seconded by Mr. Kildee, and unanimously passed by the committee that the same classes of animals should be used in this year's contest as in that of last year.

It was unanimously decided that the judge should decide the value of the various combinations used by the students in placing the animals of each class; that all the coaches should be present when the animals of any breed are placed by the judge; that the judge should explain to the coaches his reasons for placing the animals and that he should dictate his reasons to a stenographer who will prepare a copy for each coach of the reasons committee of that breed, and also prepare a couple of copies to be placed on file among the permanent records of the contest.

It was unanimously decided that being an alternate on a team of a previous year should not debar a student from taking part in the contest.

Each member of the committee was given a definite bit of work along the line of securing additional prizes.

The committee decided that the per cent marks should not be limited to multiples of five, and that 15 minutes should be allowed to students to judge each class of animals regardless of whether reasons were to be written or not.

(Signed) J. C. McDowell,
Secretary.

Report of committee on dairy cattle score cards. W. M. Regan, chairman

The committee endeavored to formulate a dairy cow score card that would apply to the present day dairy cow, that would be acceptable to the majority of instructors, and understood by dairymen and students who do not have the help of a competent instructor. The old card made no attempt to indicate the relation between form and function.

The committee wrote to fifty-two institutions in the United States and Canada asking for copies of cards and suggestions for revision. Reports indicated that fifteen colleges use the old form of card, seventeen use a card that emphasizes the relation between form and function, and four use both. The committee believes adaptation of a standard score card is not vital for college instruction, but does believe that it is vital for the boys and girls who are studying dairy cows, and who have not had impressed upon them the relations between form and function.

Score card for dairy cows

SCALE OF POINTS	PERFECT SCORE	PER CENT CUT	STUDENTS SCORE	CORRECTED
I. Characteristics Indicating Dairy Form:				
(A) Style and general appearance—20 points				
1. Head erect, clean cut; neck slender, eye prominent, alert and placid	3			
2. Back straight and strong; hips wide apart and level	4			
3. Rump long, wide and level; thurl wide apart and high; level tail setting	5			
4. Legs straight, bone fine	3			
5. General build rugged and large for the breed without coarseness; Jerseys 950 lbs.; Guernseys and Ayrshires, 1100 lbs.; Holsteins, 1350 lbs.	5			
(B) Dairy Conformation—15 points				
6. The cow should be clean cut with feminine appearance; absence of tendency to lay on fat	5			
7. Shoulder, withers, vertebra, hips and pin bones prominent and free from fleshiness (period of lactation to be considered)	4			
8. Loin wide; ribs long and wide apart	3			
9. Disposition active, with good nerve control	3			
II. Characteristics Indicating Constitution, Vigor and Condition—15 points				
10. Chest broad and deep with well sprung ribs	8			
11. Nostrils—large and open	2			
12. Condition—thrifty and vigorous, in good flesh but not beefy	5			

SCALE OF POINTS	PERFECT SCORE	PER CENT CUT	STUDENTS SCORE	COR-RECTED
III. Characteristics Indicating Ability to Consume and Digest Feeds—15 points				
13. Muzzle large; mouth broad	1			
14. Skin mellow, loose, medium thickness showing good circulation and secretion; hair soft	4			
15. Barrel deep, wide and long, well supported; ribs far apart	10			
IV. Characteristics Indicating Well Developed Milk Secreting Organs—35 points				
16. Udder:				
a. Capacity—large in size	7			
b. Quality—pliable, free from lumps	7			
c. Shape extending well forward and well up behind, level on floor, not pendulous, quarters full and symmetrical	6			
17. Milk veins—large, long, crooked and branching; milk wells large and numerous	7			
a. Milk veins on udder crooked, numerous and large	3			
18. Teats—convenient size, uniform and well placed	5			
	100			

Note: In case of any marked deficiency or any serious abnormality, as many as fifty points may be deducted from the total score of an animal. Beware of giving a thin beef cow as good a score as a dairy cow.

THE RELATION BETWEEN SKIN COLOR AND FAT PRODUCTION IN DAIRY COWS[1]

LEROY S. PALMER

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It is well established that a high yellow color in the skin secretion of dairy cattle is indicative of their ability to produce milk and butter of a high yellow color. A belief exists among Guernsey and Jersey breeders that yellow color in the skin secretions is also related to high fat production.

Definite correlation between skin color and egg production in laying hens is known to exist (1). The correlation, however, is between high egg production and low skin color. It occurs only near or at the end of the laying season.

The origin of yellow color in the skin and egg yolks of fowls, like the origin of yellow color in the skin and butter fat of cows, is the carotinoid pigments in the diet. In fowls xanthophyll carotinoids are chiefly involved, while in cows it is carotin itself.

Palmer and Kempster (2) have shown that the xanthophyll in the hen's diet is deflected entirely to the ovaries during egg laying thus causing the skin to fade because of the removal of the supply of pigment for the skin which normally acts as one of the paths of excretion.

If any physiological relation exists between milk fat production in cows and egg yolk fat production in hens it is suggested that if any correlation exists between skin color and fat production in milking cows of certain breeds, it should be between low skin color and high fat production. As in the case of hens, however, such a correlation would occur only near or at the close of lactation before the cow goes dry and has an opportunity to restore the color lost from the skin. Hens which have stopped laying quickly restore the natural yellow color to their skins on xanthophyll-containing foods.

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[1] **Abstract of paper read before the Production Section of the American Dairy Science Association, St. Paul, Minnesota, October 10, 1922.**

Hooper (3), who has studied the possibility of a correlation between high color and high fat production, could discover no such relation. Certain of his data, however, indicate a correlation between low color and a higher fat production such as is suggested. The stage of lactation at which Hooper made his color observations is not stated in connection with his data.

It is proposed that those who are in a position to make observation on this question collect data to determine whether the character of the correlation suggested actually occurs. One result of such a study will be to place on a more scientific basis the ideas which are popularly held among certain breeders as to the relation between skin color and fat production.

REFERENCES

(1) Blakeslee, Harris, Warner, and Kirkpatrick: Storrs (Conn.) Agri. Exp. Sta. Bull. 92, 95–194, 1917; Harris, Blakeslee, and Warner, Genetics, ii, 36–77, 1917.
(2) Palmer and Kempster: Jour. Biol. Chem., xxxix, 313–330, 1919.
(3) Hooper: Kentucky Agri. Exp. Sta. Bull. 234, 159–161, 1921.

DAIRY NOTES

California. Wm. Regan, for three years in charge of the dairy work at New Jersey College of Agriculture, is now in charge of dairy production work at the University of California located at Davis, Cal.

G. M. Drumm, a graduate of the Kansas State Agricultural College and the Iowa State College, has been appointed dairy herdsman at the University of California at Davis.

Idaho. G. C. Anderson, a graduate of the Kansas State Agricultural College, 1921, is assistant in dairying at the University of Idaho, Moscow, Idaho.

Iowa. A. C. McCandlish, for several years in charge of dairy production work at Iowa State College, has resigned his position and has returned to his home in Scotland where he hopes to establish a herd of Holstein-Friesian cattle. Earl Weaver has been promoted to the position made vacant by Mr. McCandlish.

Kansas. B. M. Williams, a 1922 graduate of the University of Minnesota, has taken the position in dairy extension work at the Kansas State Agricultural College made vacant by W. T. Crandall. Mr. Crandall is extension dairyman at Cornell University.

North Dakota. G. C. Biggar, a graduate of the North Dakota State College, has been appointed assistant in the dairy department at that institution.

Pennsylvania. E. B. Fitts, for many years in charge of dairy extension work at Oregon Agricultural College, is now in charge of dairy extension in Pennsylvania with headquarters at State College, Pa.

Texas. George P. Grout, for many years manager of Jean Duluth farm at Nickerson, Minn., has assumed his new duties as Head of the Dairy Department at Texas A. and M. College.

DAIRYING IN VERMONT IN THE 70's AND 80's

J. L. HILLS

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Received for publication November, 1922

It is not known, so far as the writer is aware, when cows first came into Vermont. Apparently they entered New England in 1624 at Plymouth, Mass. The State was first permanently settled from the south in 1755. Probably the hardy pioneers who came up the Connecticut Valley brought cows with them. How good they were can not be told, for in the old town records of Hadley, Mass., 30 miles south of the site of Vermont's first permanent settlement, it is stated that the cows gave so little milk, particularly during the winter, that some of the babies had to be brought up on cider. Thanks to the late Governor Hoard and to the present Mr. Volstead "it never can happen again."

The Vermont state seal pictures a cow. It is the only state seal which in any way recognizes the dairy industry. Plows appear on thirteen state seals; sheaves of wheat on nine; sober Connecticut, the land of steady habits, displays upon its seal three grapevines; Utah, a busy beehive; and Tennessee blazons the word "Agriculture" across the middle of its seal. On Vermont's seal only, however, is portrayed the likeness of the cow. She is rather blocky in form, for the wedge shape had not been thought of when she took her stand underneath the pine tree, but there she is. Tradition has it that during the Revolutionary War a British officer held in captivity near Burlington, etched on a horn the outline of Mounts Mansfield and Camel's Hump, as seen from an outlook on the farm belonging to Ethan Allen of Ticonderoga fame, now a public park. He is said to have included in his picture a large pine tree and an old cow, both of them in the foreground at the time when he was at work. Tradition further declares that the state seal was made in the 1790's from this crude etching. However, regardless of the way in which bossy wandered into the picture, certainly it is meet and right that she should have done so; for throughout the censuses from 1790 to date, Vermont has led every state in the Union in respect to her cow population per unit of improved land.

The writer has been unable to find anything authentic as to the status of dairy husbandry in Vermont during the last half of the eighteenth and the first two-thirds of the nineteenth century. There were cows in plenty and butter and cheese were made and sold from private dairies. There is ample testimony, however, as to the situation from the early seventy's onwards.

Vermont dairymen first fore-gathered in the fall of 1869 and formed the first Dairymen's Association in the country. Some twelve years ago, the Hon. Homer W. Vail of Randolph—long-time breeder of registered Jersey cattle, one time member of the executive committee of the American Jersey Cattle Club, still living, far along in years and personally in touch with Vermont dairying for sixty years—addressed the Vermont Dairymen's Association concerning early dairying in Vermont. He said, touching the conditions when the first meeting was held in the winter of '69–'70, that

> The old native cow reigned supreme. Very few herds of purebred cattle and practically few grades of the milking breeds were to be found in the State. Nobody had learned the value of early cut hay or the superior worth of clover. The only grain fed was cornmeal with sometimes oat mixture. No cottonseed meal, gluten meal or oil meal were used and bran was frequently run into the stream as a refuse, as is sawdust at lumber mills today. There was no general knowledge as to balanced rations for domestic animals. Had any scientist then ventured to talk to the Vermont farmers concerning microbes, protein or carbohydrates, he would have been thought impractical if not insane.
>
> Butter was made from cream skimmed from milk set in small 10-quart pans. There were no creameries and I have been unable to find notice of cheese factories at that period in Vermont.[1] There was no such thing as the deep setting of milk; no use was made of large pans;

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[1] As a matter of fact, C. S. Baldwell established a cheese factory in West Pawlet, Vt., on the New York state line which continued in operation until 1921; and there may have been others.

there were no separators; there was no manufacture of dairy goods in a large way. There were no veterinary surgeons to advise concerning animal diseases, and very little general knowledge as to their cause, nature, symptoms or remedies. There were some cow doctors who, like poets, were "born not made," and "horn-ail" was the popular bovine malady.

At its initial meeting in 1870, Mr. X. A. Willard, of Herkimer County, New York, the dairy editor of the Rural New Yorker, perhaps the outstanding dairy authority of the day in the East, addressed the audience. From the statements that he made may be culled the following: That "fat globules were enveloped in their shells of curd or casein;" that "milk of an average good quality (contains) 3.43 per cent butter;" that "milk varies in character from various causes, but chiefly in the butter and milk sugar, the casein showing but slight variation;" that "milk of the best quality and cheese of the best flavor comes only from good upland pastures" regardless of "what the theorists may say;" that odors in the air tainted milk "even before it was drawn;" that "small particles of milk in the corners of pails or open utensils when exposed to the air rapidly decompose and . . . . reproduce themselves;" that "when curds are exposed to the atmosphere the external parts become rapidly oxidized;" that "oats are considered to increase the quantity, barley the richness of the milk;" that "the Orange County buttermakers find (no churn) which they like so well as the old barrel dash churn;" (Orange County, New York was the acme of butter making regions in those days).

At this 1870 meeting, statements were made by some of the best informed dairymen of the day, to the effect that "not over 1 per cent of the market butter of this country is strictly prime" and that "the average price is not over one-third of that of the first quality goods;" that "in many large establishments the ancient ladle and bowl are still the only implements used for working butter;" that "the processes pursued by practical dairymen are not sufficient to secure perfect separation of the butyraceous particles;" and that "salt is used to aid in that separation and to preserve the casein or curd left in minute particles in the butter." The same speaker cited the fat content "of good milk from the milkman's can" at "2.88 fat."

He indicated that "heavy return pails well painted on the outside" were largely used for the packing of Orange County butter, the best New York market butter then made. Pails, firkins and tubs were commonly employed. The small box or package was "not commended" on the ground that "it only answers the same purpose as a sheet of brown paper . . . . . useful for families who get their supply weekly and do not care to receive it in form for the table." "A thick, solid return pail of a size adapted to a family's wants for a month is better for both producer and consumer." Prints were uncommon but pound balls "wrapped in a plain linen napkin (carrying) the name of the maker and number of the stall where sold" were sold "the producer, when he comes for the next ball, returning the napkin, neatly ironed and folded ready for use again." It is interesting to note that "the system of marketing which prevails in the neighborhood of New York City is for the producer to send his products once or twice a week to market by a man called a captain, from the fact that formerly this service was all performed by captains of North River barges." The Vermont markets were largely local. Shortly before the Civil War, the Central Vermont Railroad began to run a refrigerator car once a week to Boston. The markets were unorganized, there was no collusion among buyers, no system of reports. In those days, the Little Falls and Utica, New York markets were large affairs.

The pictures of cattle published in the dairy books, pamphlets, etc., were interesting. Of five pictures of Ayrshires and Shorthorns published in this early report, one shows slightly the wedge shape, three are as nearly rectangular as may be, and one shows a reverse wedge shape.

The Secretary of the Massachusetts State Board of Agriculture —himself a university trained man and a farmer, the father of my first college room-mate—in 1871 told the Vermont dairymen that "the Boston milk supply is a disgrace to civilization;" that "there is a row on between producers and contractors, the latter being too strong for the former;" and that "all the milk is produced within 40 to 50 miles of Boston." In those days, milk was sold raw, more or less—and probably more—dirty, with little or no inspection. Adulteration was common, dipped milk universal, and the cream trade unknown. The butter then sold was almost all dairy butter. There were no separators or deep setting devices. It was made from shallow settings, skimmed more or less completely, the cream irregularly ripened, the butter more or less mottled and sold in large packages, with quality variable and prices fluctuating, but low. There was but little winter dairying. Butter was "put down" for the winter.

In the early seventies, ice cream was almost unknown. The writer was brought up, as a child, in Boston. The only ice cream he ever knew, in the early seventies, was sold by "Billy Nichols," a peripatetic vender, who rambled about the streets ringing a bell. As a boy, he remembers freezing a small quantity of ice cream in a tinpail which he painfully twisted back and forth for an hour or more in a bucket of broken ice. Family size ice cream freezers were almost unknown. There was no such thing as an ice cream parlor. Ice cream was not purveyed at drug stores or candy stores; indeed, there were almost no candy stores then. If one had ice cream half a dozen times during the summer in small quantities, he was doing remarkably well. It was never used as a dessert.

The writer came to the University of Vermont and the Vermont Station in 1888. He promptly took up work in connection with the study of dairy manufactures. Butter was then made from milk set in a shallow pan, or in the so-called "Orange County pan," a rectangular device, or in the so-called "Ferguson Bureau" creamery, wherein pans were assembled in bureau style, or in the deep setting cylindrical cans surrounded by water, the so-called Cooley or Stoddard cans. Factory separators were just beginning to come in, the first two in the State being owned by the late F. L. Evarts, of Vergennes, and by E. J. Parker of Grand Isle, now living, about eighty years of age, the only living charter member of the fifty-two year old Dairymen's Association, the only man who has attended 51 meetings. There were no farm separators. The factory separators were mostly of the so-called Danish-Weston type. These were built upon the general lines of the modern centrifugal washing machine. They were wide open—one could throw a cat in when the thing was running and the mechanism would probably skin the cat and deliver the skin from one spout and the body from the other. There were very few creameries and these dealt mostly with the product of the deep setting cans.

There was no Babcock test. Payments were made according to many systems. There was the flat payment system, all too commonly in vogue. There was the "space" system, whereby the volume of cream was read against a glass gauge set into a cylindrical can. All spaces looked alike and were held to be alike, although actually highly unlike in their butter fat contents. There was the "gang churn" system, whereby small samples of creams from Smith's, Jones' and Brown's dairies were separately churned in the same churn, made up of a number of compartments, payments being based upon the weight of the butter churned from each sample. There was the "oil test churn," where small quantities of cream from the various dairies were churned in test tubes, the butter melted and the volume of the melted fat determined.

Under such circumstances, there was necessarily much inaccurate work done and farmers were sorely tempted to extend their milk. The writer visited many Vermont creameries and communities in the pre-Babcockian days, took samples, brought them to the station laboratory and tested them; and in the early days of the Babcock test he did the same thing. Some of his findings were interesting. In one community, 39 out of 40 samples of milk showed either watering, skimming or both. One sample was so thin that 115 pounds of milk were needed to make a pound of butter. The plea of the farmer was that he only had two or three cows, that the day before had been Thanksgiving and that his wife wanted the cream for dinner. At another location, a very thin milk was found, whose seller claimed that what he did was justifiable in that there had been a strawberry festival at the church the night before and he had given the cream to the Lord. The writer once found a fish in the sample dipper at creamery on the shores of Lake Champlain. Angle worms were frequent inhabitants of milk. In one case the farmer's pump was found to be full of angle worms. His alibi was that he had held the milk uncovered under an apple tree during the night and that undoubtedly the worms had crawled up the tree trunk, out on the branches and had dropped into the milk. In another case, the presence of an uncrated Babcock tester in the creamery served immediately to drop the number of pounds per pound of butter from 27 to 22 pounds. Almost invariably, when the writer stayed two days at a creamery most of the milks were of better quality on the second day than they were on the first.

There was much to be said on the side of the dairy farmer of the eighties and nineties. When milk is paid for on a flat basis, regardless of quality, the dairyman who is making a relatively rich milk is greatly tempted to extend it. It is an open question whether, as a matter of fact, the introduction of the Babcock test into many communities did not conduce quite as much to the spread of morality as did the expoundings from some country pulpits.

The first, or nearly the first, hand separator in Vermont was placed on the University farm in 1888. It was hand run—there was no such thing as motors in those days—and skimmed 300 pounds to the hour.

Throughout the nineties the Babcock test was greatly misunderstood and distrusted. It was reviled as being inaccurate and the operators were said to be careless or worse. All kinds of legislation was proposed with a view to remedying the situation, which of course long ago has thoroughly settled down. As a result of this agitation and the obvious necessities of the case, glassware and machines are periodically inspected, operators are examined and licensed and there is a provision whereby any aggrieved patron, believing that the tests are faulty, may call for help from the Commissioner of Agriculture, who is empowered to enter upon the premises, to take charge of and to test all samples at a given creamery where there is reason to believe that inaccurate work is being done.

In 1877, at the eighth meeting of the Vermont Dairymen's Association, Mr. Willard, who was quoted early in this article, set forth "the history of American dairying." His statements had to do mainly with cheese. In the course of his remarks, he contrasted "the flood of light which now illumines the path of the dairyman with the meagre knowledge which he possessed twenty years ago." It may be justly claimed that in the forty-five years which have elapsed since Mr. Willard made this statement, the illumination has considerably increased in brilliancy. One can only conjecture how extensively our children of 1970 will be "lit up."

THE ALCOHOL TEST AS A MEANS OF DETECTING ABNORMAL MILK

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In the methods of determining the quality of milk, the alcohol test has not yet found a very important place. Many investigators have found this test to be of great value, but in a practical way, have not been able to agree on its merits for use in the milk-receiving room. Other quality tests are employed, but the one most universally used is the acid test, even though its defects have become generally recognized. It is well known that the present acid test does not indicate the true acidity, since the casein and salts combine with the alkali, which, at times, results in an apparent high acidity in fresh milk. Under any conditions dairy manufacturing plants, and especially condenseries, would welcome any rapid and accurate test that would determine the quality of milk received. It is the object of this paper to throw more light, if possible, on work already done on the alcohol test, that it may, in some way, hasten the perfection of a reliable test.

Unfortunately, scientific investigators who have studied the alcohol test have drawn varying conclusions and disagree widely as to its value. Of those who have worked with it, Morres (1) is probably the most ardent supporter. He and other advocates claim it to be of great value, since it offers a quick and simple means of determining the condition and keeping quality of milk. We, are inclined to believe, with Campbell (2), Ernst (3), and Auzinger (4), that the alcohol test is of value, in that a positive reaction may be indicative of a chemical change in the milk. We base our belief on the studies of several cases of abnormal milk which were brought to the attention of this laboratory.

Before going into the details of these cases, it may be well to state that we have no definite conclusions to offer, other than those presented by the observations made, and we do not wish to convey the opinion that silage should not be fed to cows delivering milk to condenseries. We are, however, of the opinion that, in certain cases, physiological conditions may be found in the cow which will result in the production of abnormal milk, with a dangerous effect on the sterilization of evaporated milk. Hunziker (5) states that there are still some condenseries that will not accept milk from silage-fed cows, and it may be that the following cases are examples of difficulties which caused these condenseries to make a rejection rule of this kind.

EXPERIMENTAL TESTS WITH MILK

During April, 1921, while running alcohol tests on all the milk received at the creamery in Grove City, Pa., two cases of positive-reacting milk were found. The first of these was brought to our attention after the patron's milk had been rejected for a week. We immediately ran some preliminary tests on the milk, having received individual samples from each cow of the herd. Table 1 shows the results.

It can readily be seen from Table 1 that no ordinary test would lead us to distinguish those milks which reacted positively from those that reacted negatively. The acidity of each sample was normal, and the bacterial counts do not indicate an unusual disturbance.

The following afternoon a visit to the farm proved that the silo had been emptied that morning. Upon examining the silage, it was found moldy and partly decomposed. Then the above tests were shown to the patron, he stated that some of the cows had refused the silage, and later, further investigation proved that the cows reacting positively to the test were the same cows that had eaten plentifully of the silage, while those reacting negatively had refused it. A few days after discontinuing the feeding of silage, this patron's milk was again accepted as normal.

At the same time these first tests were being run, a similar case was brought to our attention where the herd milk reacted positively to the alcohol test. Table 2 shows the results of the preliminary tests:

Again we found nothing that would give us a clue to the cause of the variation of positive and negative results, but the experience

TABLE 1

Milk from first herd fed moldy silage

NUMBER OF COW	FERMENTATION TEST	ALCOHOL TEST	BACTERIA COUNT	ACID TEST	FLAVOR AND ODOR
1	Very gassy	+	100,000	0.18	Flat
2	Good	–	250,000	0.175	Fair
3	Good	–	140,000	0.17	Good
4	Good	–	100,000	0.165	Good
5	Good	+	180,000	0.155	Flat
6	Slightly gassy	–	90,000	0.165	Fair
7	Good	+	250,000	0.16	Fair
8	Good	+	100,000	0.165	Good
9	Good	–	500,000	0.17	Flat
10	Good	+	300,000	0.165	Fair
11	Good	+	300,000	0.165	Good
12	Good	–	90,000	0.17	Good
13	Good	–	90,000	0.155	Good
14	Good	+	100,000	0.16	Good
15	Good	–	100,000	0.16	Fair

TABLE 2

Milk from second herd fed moldy silage

NUMBER OF COW	FERMENTATION TEST	ALCOHOL TEST	BACTERIA COUNT	ACID TEST	FLAVOR AND ODOR
1	Slightly digested	+	50,000	0.16	Good
2	Good	+	100,000	0.17	Fair
3	Slightly gassy	+	75,000	0.155	Off, flat
4	Good	–	75,000	0.18	Good
5	Good	–	60,000	0.185	Good
6	Good	+	85,000	0.16	Fair
7	Slightly digested	–	100,000	0.165	Good
8	Good	+	100,000	0.155	Good

in the first case led us to believe that the silage might be causing the trouble here, so the farm was visited at once. The cows of this herd had not yet been on pasture. We examined the concentrates and hay and found nothing in them that would tend to cause a disorder in the cows, but the silage, as in the first case, was moldy. This silo also was nearly empty. We took the liberty of feeding each cow a forkful of silage, and found that some accepted while others refused it. Correlation between the silage and the reaction was again in evidence, as those accepting the feed reacted positively, while those refusing it reacted negatively. At our suggestion the silo was emptied and the cows put on a different ration, and within a few days the reaction of the herd milk went from positive to negative.

Throughout the rest of the year, alcohol tests were made on the herd milk, but no cases of abnormal milk were found. But in April, of this year, a case similar to those of 1921 came up, and as there was enough silage left, a series of experiments was immediately begun. The silage here was moldy around the outside and also in spots through the center. The farm was visited, and the three cows of this herd whose milk reacted positively to the alcohol test were isolated. Cow 1 was put on a ration from which the silage was eliminated, and cow 2 was fed normally, as a check. For the reason that some rich clover hay was being fed, cow 3 was fed a ration with silage, but with the clover hay eliminated. On the fifth day, the milk from cow 1 cleared up in the alcohol test, while the milk from cows 2 and 3 continued to react positively. Cow 1 was then put back on silage, and in four days her milk again reacted positively. The experiment was then changed, putting cow 2 on a ration without silage and using cows 1 and 3 as a check. In four days the milk from cow 2 reacted negatively to 'the test. By this time the silage was gone and we were, therefore, forced to discontinue the experiment. Table 3 shows the results of the preliminary tests:

TABLE 3

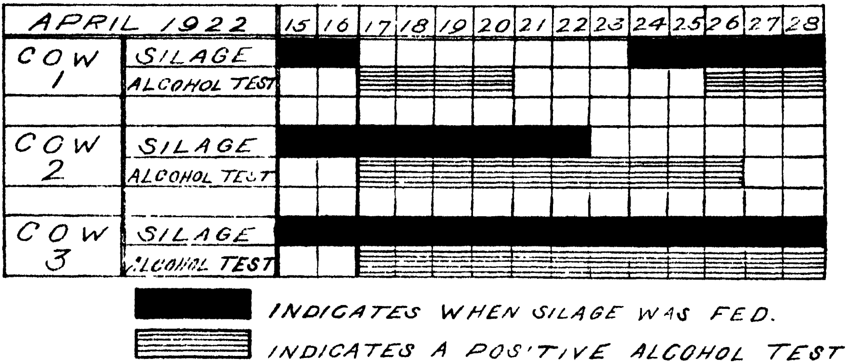
Milk from third herd fed moldy silage

NUMBER OF COW	FERMENTATION TEST	ALCOHOL TEST	BACTERIA COUNT	ACID TEST	FLAVOR AND ODOR
1	Good	+	2,500	0 155	Good
2	Good	+	18,000	0.15	Good
3	Good	+	20,000	0.155	Good

It might be well to state that cow 1 was in the middle of her lactation period and cow 2 near the end, while cow 3 was fresh.

A graphic illustration (fig. 1) will perhaps show better the outline and results of the experiment.

In our estimation, the above experiment would tend to prove that in some cases poor silage will affect the physiological condition of the cow in such a way as to cause her milk to become abnormal. It would seem quite evident that in the three cases enumerated, the silage was the cause of the abnormal milk; and if it were possible to make a complete analysis of the cows' milk and the silage, it would perhaps determine the exact cause for this disorder. However, it is rather doubtful whether chemical analysis would disclose the reason for this change. Ayers and Johnson (6) have shown that a positive alcohol test indicates some change in the milk from its normal condition, and their results also show that there is no definite relation between the alcohol test and the number of bacteria present in the milk. It would, therefore, be safe to say that this physiological disorder has induced a chemical change in the milk which causes it, when tested with alcohol, to coagulate.



APRIL 1922		15	16	17	18	19	20	21	22	23	24	25	26	27	28
COW 1	SILAGE	■	■								■	■	■	■	■
	ALCOHOL TEST			▤	▤	▤							▤	▤	▤
COW 2	SILAGE	■	■	■	■	■	■	■	■						
	ALCOHOL TEST			▤	▤	▤	▤	▤	▤	▤	▤	▤	▤		
COW 3	SILAGE	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	ALCOHOL TEST			▤	▤	▤	▤	▤	▤	▤	▤	▤	▤	▤	▤

■ INDICATES WHEN SILAGE WAS FED.

▤ INDICATES A POS'TIVE ALCOHOL TEST

FIG 1

TESTS WITH EVAPORATED MILK

Dahlberg and Garner (7), in their work on determining the quality of milk for condenseries, have found that the alcohol test, in some cases, is very valuable, while in others it has not proved satisfactory. However, they found at the Grove City creamery, in the case of milk reacting positively, the sterilization point of the evaporated milk was very low. We, therefore, ran some of the milk from each cow through our laboratory condenser, to determine whether a variation in their coagulating points could be found from the time the milk reacted positively until after it had changed from positive to negative. Table 4 shows the results obtained.

TABLE 4

Condition of evaporated milk from cows in feeding experiment

	cow 1	cow 2	cow 3
Alcohol test	+	+	+
Acidity	0.15	0.155	0.15
Fat	4.6	4.3	4.0
Total solids	14.02	13.90	13.18
Solids not fat	9.41	9.60	9.18
Forewarming temperature, degrees Fahrenheit	90	92	90
Total solids on evaporation	26.92	27.01	26.14
Coagulating point, degrees Fahrenheit	215	222	228
After milk from cow 2 had changed to negative reaction			
Alcohol test	+	−	+
Acidity	0.155	0.15	0.165
Fat	4.65	4.2	4.2
Total solids	14.02	13.4	13.52
Solids not fat	9.37	9.2	9.32
Forewarming temperature, degrees Fahrenheit	90	90	90
Total solids on evaporation	26.50	26.95	27.05
Coagulating point, degrees Fahrenheit	214	230.5	226

It will be noted that there is a difference of 8.5°F. in the coagulating temperature of the milk of cow 2, while for Cows 1 and 3 the change was 1 and 2°F., respectively. This would tend to show that a positive-reacting milk has a lower coagulating point in the case of abnormal milk, and that as soon as it becomes normal or the cause of the abnormality is removed, the coagulating point rises.

In conclusion, we wish to point out that the alcohol test is of value in determining some cases of abnormal herd milk, and especially those which would prove to be harmful to condenseries. We also believe that a poor quality of silage must be watched, so that no ill effects may come from it. As stated before, there can be no other conclusions drawn in the cases enumerated, than that the silage was the cause of the abnormal milk.

We are also inclined to believe that the mono- and dibasic phosphate salts played an important part in the phenomena we have described.

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STUDIES IN MILK SECRETION

X. RELATION BETWEEN THE MILK YIELD OF ONE LACTATION AND THE MILK YIELD OF A SUBSEQUENT LACTATION IN GUERNSEY ADVANCED REGISTRY CATTLE[1]

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To be worthy of consideration an advanced registry record must do two major things: First it must predict with reasonable accuracy what the production of that cow will be in subsequent lactations; second, it should indicate, in some degree at least, what milk production may be expected of that cow's offspring. Surprising as it may seem in view of the constantly recurring assertion of the desirability of the advanced registry test, there is very little foundation of proof to support these two hypotheses. It appears beyond cavil, if an advanced registry cow who makes an excellent record on test is worthless as a subsequent milk producer or if a cow of poor test is the leader in the breed at a subsequent lactation, that the value of the advanced registry records of these cows is slight indeed. Now it may be asserted that cases can be cited which will show that the advanced registry record indicates a cow's true worth. True enough, but these are selected cases. They do not indicate the value of the test for the whole breed. It is to furnish data on this point for the advanced registry of one whole breed, the Guernsey, that this paper is written.

MATERIAL

The American Guernsey Cattle Club in its advanced registry tabulates the records of the cows which make the requirements for entry. In volume 31 of this registry there are found to be 738 possible pairs of these tests and retest for cows under ten years old. From these data the necessary tables were formed to determine the relationship between the milk production of one lactation and that of another. These tables are shown in the appendix to this paper. Because of the effect of age on yield it was deemed advisable to divide the data into year groups up to the age of seven years. The ages of seven, eight, and nine years are grouped together. The precautions taken by the cattle clubs and the supervision of the records by competent men should make these data accurate.

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[1] Paper from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 144. This paper is one of a series of investigations in animal husbandry the continued prosecution of which has been made possible by a grant to the author from the Rockefeller Institute for Medical Research.

The methods used are those in ordinary biometrical use.

MEAN MILK YIELD OF GUERNSEY TEST AND RETEST COWS

The average milk yield for each of the different age groups is shown in table 1.

The columns represent the mean milk yields of the age group indicated above the column. The groups within that age for which the milk yields are subsequently correlated are shown at the left as the age at which the retest was made. Thus the first mean in the two-year column, 8519 ± 129, shows that these two-year-olds mean milk yields was 8519 ± 129 pounds and that these same cows were subsequently tested at three years old. Similarly the mean milk yield of the two-year-olds subsequently retested at four years old was 8248 ± 104. The mean milk yield of the three-year-old cows tested at two years is given in column headed three years in the two-year row as 10349 ± 163.

Table 1 shows several significant points. The milk yields for these two-year-old cows tested at subsequent dates are approximately the same as those of the average two-year-old advanced registry Guernsey cows. This means that no selection of better milking cows for subsequent retest has taken place within this two-year-old group.

If the column for the three-year-old cows is compared with the average of the advanced registry Guernsey cattle, it is found that the three-year-old cows which were tested at two years old produced in their three-year-old lactation something over 1300

TABLE 1

Average milk yield of Guernsey test and retest cows

AGE WITH WHICH CORRELATED	AGE CORRELATED						
	2 years	3 years	4 years	5 years	6 years	7, 8, 9 years	7 years
years	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
2		10349±163	10630±150	12274±225	11864±237	11545±239	
3	8519±129		10791±229	11709±226	11971±282	11647±240	
4	8248±104	9027±186		10924±271	11738±264	12420±350	
5	8311±168	9267±221	9136±189		11778±343	12000±240	
6	8659±186	9294±261	9810±239	10556±251		12368±350	
7, 8, 9	7545±142	8324±191	9300±219	9969±200	10494±243		11364±350
8 and 9							12909±359

pounds more milk than was expected of them. Examination of the three-year-old cows which were not tested for advanced registry at two years old shows their milk yield to agree, within the limits of random sampling, with the average of all the Guernsey cows tested at this age. Clearly here is proof of what fitting and care will do for increasing milk yield. But let us examine the four-year-old cows. Here the same facts are brought out. The cows tested at two years or at three years old produce more than the average advanced registry cow of four years by an amount equal to 1200 pounds on the average, whereas those cows tested for advanced registry for the first time produce practically that of the average for all the advanced cows of this breed an age. The five-year-old cows tested as two, three or four year olds produced nearly 1500 pounds of milk more than did the average of the five-year-old advanced registry cows, whereas the cows tested at five years old for the first time produced only slightly more than the average of all advanced registry Guernsey cows. The six-year-old cows when previously tested produced about 1300 pounds more milk than the average of all the advanced registry Guernsey cows of that age. The six-year-old Guernsey cows not previously tested produced practically the same milk yield as the average six year-old cows. The seven-, eight-, and nine-year old cows where previously tested, produced on the average 2,000 pounds of milk more than the average of all the advanced registry cows. These facts indicate the universality of an increase in retest milking of the Guernsey cows with previous advanced registry tests. There is no clear evidence that the difference increases significantly with the older ages and consequent increase in milk yield. The fact of the increased milk yield after a previous advanced registry test may be accounted for in at least four ways.

(a) That the previous test has enlarged and developed the udder of cows so tested beyond what it would ordinarily have been.

(b) That the owner of the cow realizing the worth of the cow due to her previous test prepares the cow better for the coming test.

(c) As a corollary to (b) that the cows get better care and feeding, in fact get extraordinary care, than they did in their first test or that any cows first tested would be likely to get.

(d) That cows, when second tested, which do not make relatively large records in the second test are not entered into the advanced registry by their owners even though they make the requirement for entry.

It is difficult to evaluate properly the relative effect of these four variables. It seems probable that (d) played but little part in the conditions cited. Thus the owner of the cow to be retested would pay $5 to start the test, plus practically $9 per month for a supervisor as long as the test was continued. This would mean on 8 cows (the maximum number which are allowed to one supervisor for 3 milkings a day) a cost per month of about $1.50 per cow. It seems highly doubtful, therefore, whether in view of the expense already made in the completion of a test the owner would deliberately keep back or withhold from the Cattle Club the names of the cows which made the requirement but did not make it by a large amount. Furthermore, with the increase in milk yield with age a cow is practically bound to increase in the actual (not her relative) yield of butter-fat. This would tend to cause all cows making the retest to be included in the advanced registry. Such a state of affairs would make (a), (b), and (c) the important factors.

These factors are strictly environmental. They represent what Galton would call nurture factor as distinct from those of nature. Here then is a measure of some environmental factors as they effect milk yield. How much are they capable of effecting milk yield? Clearly from one-sixth to one-ninth of its total amount. As a strictly biological fact where environmental causes may impose variations of so great a magnitude upon genetic characters, it devolves upon the breeder and tester of dairy cattle to make full use of this variation by carefully fitting his cows for advanced registry work.

VARIATION OF THE MILK YIELD OF GUERNSEY RETEST COWS

Table 2 gives the amount of milk which these Guernsey cows varied on their first and second tests. This is recorded as the standard deviation. Within a range of three times the standard deviation on either side of the mean will be included practically all the observed milk yields. The arrangement of the table is the same as that of table 1.

The variability within the different age groups appears to be at random. The variability of the two-year-old class is less than that of the other age classes. This is in accord with the results of other investigations (1) where it may be shown that the standard deviation of milk yield rises rapidly with age, following, in general, one form of a parabola. The percentage of this variation in comparison with the mean milk yield ranges from 14 to 25. This range is about that of most milk-producing cows and breeds when calculated from relatively small groups similar to those of these data.

RELATION BETWEEN THE MILK YIELD OF THE FIRST TEST AND OF THE RETEST

We are now in a position to obtain the answer to the problem, does an advanced registry record predict with reasonable accuracy what the production of a cow's retest will be in a subsequent lactation? The amount of the correlation coefficients for the relation between the test and retest shows the degree of reliance which can be placed in an advanced registry test as a means of predicting the subsequent milk yield of the same cow. Thus, if a cow produces the highest milk yield of all two-year-olds, will she produce the highest milk yield of all three-year-olds? That is, will a cow maintain the relative level of her production among her sister cows which she had in the previous lactation? If so the correlation coefficient will be 1.000. If it makes no difference what the first test is, whether the highest or lowest, in determining what the subsequent test will be the correlation coefficient will be zero. The range between 1 and 0 determine the value of the first test record as a prediction of the milk yield of the subsequent

TABLE 2

Differences between milk yields of Guernsey retest cows in first and second tests

AGE WITH WHICH CORRELATED	AGE CORRELATED						
	2 years	3 years	4 years	5 years	6 years	7, 8, 9 years	7 years
years	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
2		2487±115	2379±106	2431±159	2327±167	2354±169	
3	1971±91		2520±162	2195±160	2440±200	2074±170	
4	1657±74	2044±131		2310±192	2534±186	2591±247	
5	1812±118	2144±156	1611±134		2155±242	2016±170	
6	1833±132	2259±185	2294±169	1580±178		2922±247	
7, 8, 9	1397±100	1653±135	1625±155	1677±141	2218±172		2436±248
8 and 9							2498±254

TABLE 3

Correlation coefficient for variation in milk yield in first test and retest of Guernsey cows

AGE WITH WHICH CORRELATED	AGE CORRELATED						
	2 years	3 years	4 years	5 years	6 years	7, 8, 9 years	7 years
2		0 795±0 024	0 586±0 041	0 701±0 047	0 775±0 041	0 462±0 080	
3	0 795±0 024		0 726±0 043	0 643±0 060	0 775±0 046	0 539±0 082	
4	0.586±0 041	0 726±0 043		0 750±0 051	0 725±0 049	0 661±0 076	
5	0.701±0 047	0 643±0 060	0 750±0 051		0 778±0 063	0 606±0 075	
6	0 775±0 041	0 775±0 046	0 725±0 049	0 778±0 063		0 811±0 038	
7, 8, 9	0.462±0.080	0 539±0 082	0 661±0 076	0 606±0 075	0 811±0 038		
8 and 9							0.808±0 050
Average......	0 664	0 696	0 690	0 696	0 773	0.616	0.808

retest. The data of table 3 answers this problem for Guernsey test and retest advanced registry cows. Study of table 3 shows that the correlation coefficients for milk yield of one lactation correlated with the milk yield of another lactation are high for this kind of data. The average correlation coefficient is 0.696 when each observation is equally weighted. The magnitude of the correlation coefficient shows that the retest record may be predicted with considerable accuracy from the record of the first test. The answer to the problem set for this paper is at hand; the advanced registry test predicts with reasonable accuracy the record obtained on retest of Guernsey cows. Records of milk yield at one age are of about equal value with those of another age in predicting the cow's subsequent record.

From the practical side of culling the poor milkers out of the herd these results are highly satisfactory. The data are equally interesting when considered in their biological aspects. The correlations show that the cows composing the herd are innately differentiated in their milk-producing abilities. The plane of production once established, the cow tends to maintain this relative plane from lactation to lactation. The values of the correlations indicate clearly that there is a fairly accurately working mechanism behind this function.

From this point of view it is of a good deal of interest to compare the only other statistics available for cattle with those derived here.

In a pure-bred herd of Jersey cattle, Gowen (2) showed that the correlation coefficients for the eight months' milk production of one lactation with that of another lactation at another age ranged from +0.2144 ± 0.0919 to + 0.7306 ± 0.0284. Each set of correlation coefficients for the milk production at a given age with the milk productions at other ages in the cow's life deviate only slightly from a line which is approximately linear, taking a nearly constant value for each age. The mean value for these correlation coefficients of milk production of one lactation at any age with the milk production of another lactation at another age is +0.5352.

On another herd composed of British Holsteins and Shorthorns Gavin, using his measure of the lactation as the "revised maximum," found the correlation between the milk productions of the various lactations and that of their maximum "revised maximum" to be those shown in table 4.

The data on the pure-bred Jersey herd and that of Gavin correspond closely. They indicate that in an unselected group of cattle a somewhat lower relation exists between the milk yield of one lactation and the milk yield of a subsequent one than is shown by the Guernsey advanced registry test and retest cows. The correlations are in all cases high and confirm each other in proving that the individual cows are innately differentiated as regards their capacity for milk production.

TABLE 4

Correlation coefficients between milk productions in various lactations of British Holstein and Shorthorn cows

LACTATION	r WITH MAXIMUM "REVISED MAXIMUM"	PROBABLE ERROR
First	+0.394	±0.031
Second	+0.452	±0.030
Third	+0.506	±0.028
Fourth	+0.605	±0.024
Fifth	+0.762	±0.016

Other relations which include productive capacity in its broad sense have been studied for dairy cattle. Eckles and Swett (3) have studied data on the relation of birth weight to the height at the withers at twenty-four months of age for the resulting calf. They say "these data possibly show a very slight tendency toward the animals larger at birth maintaining a lead over the normal during the period of most rapid growth, but individual variations are marked." The author has calculated the correlation coefficients for these data of Eckles and Swett. For the relation between birth weight and wither height of the 13 Holstein-Friesian heifers the correlation coefficient is 0.29; for the 12 Jersey heifers 0.24. The conclusion of Eckles and Swett to this extent appears justified. However, when it is realized that on samples of the size of 13 and 12 correlation coefficients of this amount would have an equiprobable range of not less than 0.20 on either side of this value, the conclusions, based on such small numbers, lose weight.

Of the quantitative data on other species of practical interest perhaps the most complete is that of Harris and Blakeslee (4) (1918) on the White Leghorn. In this work they determined the correlations between the monthly egg production and the other eleven months production of the same bird. The correlations for these monthly ovulations with the other eleven months ovulation takes values ranging from $+0.240 \pm 0.033$ to $+ 0.573 \pm 0.023$. The range is there quite similar to those obtained in the data for milk yield in cattle although lower in value. The knowledge of these sets of constants gives criteria for the fairly accurate prediction of the records that may be expected at a subsequent date in the life of these extremely economically important species.

PREDICTION OF RETEST MILK YIELD FROM FIRST TEST MILK YIELD

To predict one variable from another as the milk yield of one lactation from that of another lactation, it is necessary to know the numerical relations between the variables. These may be determined in the form of equations. The equations to predict the probable yield on the second test of Guernsey cattle making advanced registry test have been calculated. These are given in table 5.

In the equations of table 5 Y represents the desired predicted milk yield at the subscript age and y indicates the milk yield at the age given as the subscript to y. Thus a cow at two years old gave a milk yield of 8000 pounds, what would be the expected advanced registry milk yield at six years of age. We find the Y of six years and y of two years in the fourth equation of column 2. The equation is

$$Y_6 = 3347 + 0.984y_2$$

substituting, we have $Y_6 = 3347 + 0.984 \times 8000$, or the expected milk yield at six years of age is 11,219 pounds. In the same manner the predicted milk yield of any age may be found.

TABLE 5

Equations to predict the probable yield of Guernsey advanced registry cows on second test

$Y_2 = 1{,}994 + 0.630y_3$
$Y_2 = 3{,}908 + 0.408y_4$
$Y_2 = 1{,}897 + 0.523y_5$
$Y_2 = 1{,}414 + 0.611y_6$
$Y_2 = 4{,}378 + 0.274y_{7,8,9}$
$Y_3 = 2{,}678 + 0.588y_4$
$Y_3 = 1{,}913 + 0.628y_5$
$Y_3 = 704 + 0.718y_6$
$Y_3 = 3{,}316 + 0.430y_{7,8,9}$
$Y_4 = 3{,}422 + 0.523y_5$
$Y_4 = 2{,}108 + 0.656y_6$
$Y_4 = 4{,}150 + 0.415y_{7,8,9}$
$Y_5 = 3{,}833 + 0.571y_6$
$Y_5 = 3{,}923 + 0.504y_{7,8,9}$
$Y_6 = 2{,}852 + 0.616y_{7,8,9}$
$Y_7 = 1{,}189 + 0.788y_8$ and
$Y_3 = 1{,}803 + 1.003y_2$
$Y_4 = 3{,}686 + 0.842y_2$
$Y_5 = 4{,}458 + 0.940y_2$
$Y_6 = 3{,}347 + 0.984y_2$
$Y_{7,8,9} = 5{,}669 + 0.779y_2$
$Y_4 = 2{,}713 + 0.895y_3$
$Y_5 = 5{,}610 + 0.658y_3$
$Y_6 = 4{,}190 + 0.837y_3$
$Y_{7,8,9} = 6{,}016 + 0.677y_3$
$Y_5 = 1{,}099 + 1.075y_4$
$Y_6 = 3{,}885 + 0.801y_4$
$Y_{7,8,9} = 2{,}613 + 1.055y_4$
$Y_6 = 570 + 1.062y_5$
$Y_{7,8,9} = 4{,}742 + 0.728y_5$
$Y_{7,8,9} = 1{,}172 + 1{,}069y_6$
Y_8 and $_9 = 3{,}492 + 0.829y_7$

SUMMARY

This study presents the data on the Guernsey breed to determine the worth of an advanced registry record for milk yield as an indicator of the milk yield of a subsequent lactation. The major conclusions may be stated briefly.

Environment may materially effect the milk yield of a cow. Thus Guersey cows on retest produced over 1000 pounds milk more than their sisters on first test at the same age.

The variation of Guernsey milk yield agrees with that of the other breeds.

The relation of the milk yield of one lactation to that of another is high, ranging from 0.462 to 0.811 in the correlation scale. Compared with a pure-bred herd of Jerseys, the average coefficient of correlation is nearly 0.15 higher for the Guernsey advanced registry cattle than it is for the Jerseys. Compared with the records for egg production, the Guernsey milk records indicate with much greater accuracy what the subsequent retest milk record will be than do the egg records for one month indicate what the subsequent eleven months' egg record will be for White Leghorn hens.

Equations are presented to determine from one lactation's advanced registry record what will be the probable record at a subsequent lactation.

APPENDIX

TABLES SHOWING THE CORRELATION SURFACE FOR THE VARIABLE MILK YIELD OF ONE LACTATION WITH THE MILK YIELD OF ANOTHER LACTATION. EACH LACTATION IS AT A KNOWN AGE

3-YEAR-OLDS' MILK YIELD (POUNDS)	2-YEAR-OLDS' MILK YIELD (POUNDS)											
	4,000 to 5,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000 to 15,000	
5,000 to 6,000		1										1
6,000	1	2	2	3								8
7,000		1	9	1								11
8,000		1	2	5	4	1						13
9,000		2	1	6	6	2	1					18
10,000			1	3	4	5	1					14
11,000				3	1	6	3					13
12,000				1	1	4	8	1				15
13,000			1	2		3						6
14,000								1	1	1		3
15,000									1			1
16,000										1	1	2
17,000												
18,000 to 19,000											1	1
	1	7	16	24	16	21	13	2	2	2	2	106

4-YEAR-OLDS' MILK YIELD (POUNDS)	2-YEAR-OLDS' MILK YIELD (POUNDS)								
	5,000 to 6,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000 to 13,000	
5,000 to 6,000	1								1
6,000		1	1						2
7,000	4	2	3	1	2	1			13
8,000	3	7	3	3	1	1			18
9,000	1	4	8	3	2				18
10,000		3	5	4	3				15
11,000			2	5	1	3	1		12
12,000			2	6	2	5			15
13,000		1	3	1	3	2	1		11
14,000			1		3		1	1	6
15,000			1		1				2
16,000 to 17,000								2	2
	9	18	29	23	18	12	3	3	115

5-YEAR-OLDS' MILK YIELD (POUNDS)	2-YEAR-OLDS' MILK YIELD (POUNDS)										
	5,000 to 6,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000 to 15,000	
7,000 to 8,000	2										2
8,000	3	2	1	2	1						9
9,000		1	4	1							6
10,000		3	5	1	2						11
11,000	1		2		3						6
12,000			1	1	4	3					9
13,000						3					3
14,000						1					1
15,000		1			2	1					4
16,000					1						1
17,000											
18,000 to 19,000										1	1
	6	7	13	5	13	8				1	53

6-YEAR-OLDS' MILK YIELD (POUNDS)	2-YEAR-OLDS' MILK YIELD (POUNDS)											
	5,000 to 6,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000 to 16,000	
7,000 to 8,000	1											1
8,000		1	1									2
9,000		2	3	1								6
10,000	1	1	2	3	1							8
11,000		1		5	1	2						9
12,000		1	1	3	1	2						8
13,000					1							1
14,000				2	1		2					5
15,000						2						2
16,000						1						1
17,000												
18,000												
19,000 to 20,000											1	1
	2	6	7	14	5	7	2				1	44

7-, 8- AND 9-YEAR-OLDS' MILK YIELD (POUNDS)	2-YEAR-OLDS' MILK YIELD (POUNDS)						
	5,000 to 6,000	6,000	7,000	8,000	9,000	10,000 to 11,000	
8,000 to 9,000	1	4					5
9,000	3	1	2	2	1		9
10,000	1	3	1	1	1		7
11,000		2	2	1	2		7
12,000		2	2	1			5
13,000			2	1	1	1	5
14,000		1	1				2
15,000			1				1
16,000						1	1
17,000 to 18,000			1			1	2
	5	13	12	6	5	3	44

4-YEAR-OLDS MILK YIELD (POUNDS)	3-YEAR-OLDS' MILK YIELD (POUNDS)										
	5,000 to 6,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000 to 15,000	
5,000 to 6,000	1										1
6,000			1								1
7,000	1	3			1			1			6
8,000		2	1	1	1						5
9,000			3	5		1					9
10,000		1	2	4		2					9
11,000		1	2	2	4	1					10
12,000				1	2						3
13,000						1	2		1		4
14,000						1	2				3
15,000						1		1	1		3
16,000											
17,000 to 18,000										1	1
	2	7	9	13	8	7	4	2	2	1	55

5-YEAR-OLDS' MILK YIELD (POUNDS)	3-YEAR-OLDS' MILK YIELD (POUNDS)													
	6,000 to 7,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000 to 19,000	
7,000 to 8,000		1												1
8,000														
9,000	1	1	3	2		1								8
10,000	3	2	2	2		1								10
11,000		1	3	4		1								9
12,000		1	1	1	1	1								5
13,000		2	1		2									5
14,000				1										1
15,000						1	1							2
16,000														
17,000							1							1
18,000 to 19,000													1	1
	4	8	10	10	3	5	2						1	43

6-YEAR-OLDS' MILK YIELD (POUNDS)	3-YEAR-OLDS' MILK YIELD (POUNDS)										
	5,000 to 6,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000 to 15,000	
7,000 to 8,000	1										1
8,000	1		1								2
9,000		2	1								3
10,000	1	1	1	1	3						7
11,000				1	1	1	3				6
12,000			2		3	1					6
13,000					1	1	1				3
14,000					1	1					2
15,000						1				1	2
16,000									1		1
17,000											
18,000											
19,000 to 20,000									1		1
	3	3	5	2	9	5	4		2	1	34

7-, 8- AND 9-YEAR-OLDS' MILK YIELD (POUNDS)	3-YEAR-OLDS' MILK YIELD (POUNDS)								
	5,000 to 6,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000 to 13,000	
8,000 to 9,000	1	2							3
9,000			1	1			1		3
10,000		1	3	4					8
11,000	1	1	2	2	2	1			9
12,000		1	1	1	1				4
13,000				1	1				2
14,000		1				2			3
15,000									
16,000						1			1
17,000 to 18,000								1	1
	2	6	7	9	4	4	1	1	34

5-YEAR-OLDS' MILK YIELD (POUNDS)	4-YEAR-OLDS' MILK YIELD (POUNDS)									
	5,000 to 6,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000 to 14,000	
7,000 to 8,000	1		1	2	1					5
8,000			1							1
9,000			1	3						4
10,000			3	6		2				11
11,000					1	1				2
12,000					2	1	1			4
13,000				1	1					2
14,000						1	1			2
15,000									1	1
16,000 to 17,000								1		1
	1		6	12	5	5	2	1	1	33

6-YEAR-OLDS' MILK YIELD (POUNDS)	4-YEAR-OLDS' MILK YIELD (POUNDS)										
	6,000 to 7,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000 to 16,000	
6,000 to 7,000	1										1
7,000											
8,000		1	1	1							3
9,000		4	1								5
10,000		3	2	2	1						8
11,000			5	2	1	1	1		1		11
12,000			2	1	1	1	1				6
13,000				1							1
14,000							1				1
15,000				1		1			1		3
16,000										1	1
17,000										1	1
18,000											
19,000 to 20,000							1				1
	1	8	11	8	3	3	4		2	2	42

7-, 8- AND 9-YEAR-OLDS' MILK YIELD (POUNDS)	4-YEAR-OLDS' MILK YIELD (POUNDS)							
	7,000 to 8,000	8,000	9,000	10,000	11,000	12,000	13,000 to 14,000	
8,000 to 9,000	2							2
9,000	1	2						3
10,000	1	1	1					3
11,000	1		2	1				4
12,000		4						4
13,000		1	1		1	1		4
14,000								
15,000								
16,000			3				1	4
17,000 to 18,000						1		1
	5	8	7	1	1	2	1	25

6-YEAR-OLDS' MILK YIELD (POUNDS)	5-YEAR-OLDS' MILK YIELD (POUNDS)							
	7,000 to 8,000	8,000	9,000	10,000	11,000	12,000	13,000 to 14,000	
7,000 to 8,000			1					1
8,000	1							1
9,000			1					1
10,000			1	1				2
11,000		1	3	3				7
12,000						1		1
13,000					1	1	1	3
14,000								
15,000						1		1
16,000 to 17,000						1		1
	1	1	6	4	1	4	1	18

7-, 8- AND 9-YEAR-OLDS' MILK YIELD (POUNDS)	5-YEAR-OLDS' MILK YIELD (POUNDS)								
	6,000 to 7,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000 to 14,000	
8,000 to 9,000	1		1						2
9,000	1	1	2						4
10,000				3	1				4
11,000			1			5			6
12,000				5	1	1			7
13,000			1	1	1			1	4
14,000				1	1		1		3
15,000									
16,000 to 17,000					1			1	2
	2	1	5	10	5	6	1	2	32

7-, 8- AND 9-YEAR-OLDS' MILK YIELD (POUNDS)	6-YEAR-OLDS' MILK YIELD (POUNDS)										
	7,000 to 8,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000 to 17,000	
8,000 to 9,000	1	2									3
9,000	3		2								5
10,000	1	1	2	1							5
11,000		1	2	3	1						7
12,000		2		3	1	1					7
13,000				1	1	1					3
14,000							1	1			2
15,000											
16,000					1	1	1		1		4
17,000											
18,000											
19,000					1						1
24,000 to 25,000										1	1
	5	6	6	8	5	3	2	1	1	1	38

8- AND 9-YEAR-OLDS' MILK YIELD (POUNDS)	7-YEAR-OLDS' MILK YIELD (POUNDS)												
	7,000 to 8,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000 to 19,000	
9,000 to 10,000		1											1
10,000	1	1	1	1									4
11,000			1	3	2		1						7
12,000					1								1
13,000				1									1
14,000				1	2	1							4
15,000					1		1						2
16,000													
17,000												1	1
18,000													
19,000 to 20,000										1			1
	1	2	2	6	6	1	2			1		1	22

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ACIDITY OF BUTTER AND ITS BY-PRODUCTS

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From the very beginning of the science of buttermaking, the acidity of cream has received much attention. At first because it was found to have an important influence upon the immediate flavor of butter. In the past decade the importance of acidity has increased because of the discovery that it profoundly affects the keeping quality as well as the immediate flavor of butter. It has been presumed too much that if the acidity of cream is right the butter will be right in so far as it is affected by acidity.

The acidity of cream comes to effect as acidity in the butter. It is the acidity in the butter that affects its flavor and keeping quality. Even though the churning acidity of cream is right the acidity of butter may be high if the butter is overchurned or if the butter is not properly washed.

The source of the acidity of cream is almost entirely in its serum or butter milk. Milk fat is neutral so far as its register upon the acid test of cream is concerned. About one half of the acidity of butter, tested with alcohol and ether, is due to buttermilk, the other half to the fat itself. If the acidity of butter is tested without a fat solvent like alcohol and ether, then the acidity measured is practically all due to butter milk.

Thorough and convenient removal of buttermilk is very desirable.

Butter granules of visible size either large or small are aggregates or clumps of smaller granules. The constitution of a butter granule can be illustrated with a barrel of apples. The barrel is full of apples and not another apple could be added. The contents of the barrel are not all apples. The spaces between the apples are occupied by air. Likewise, a visible butter granule is not all milk fat. The spaces between the microscopic granules composing the large granule are full of buttermilk.

For the purpose of the problem in hand, granules the size of filberts are aggregates of granules of the size of wheat. It is obvious that wash water has a much greater distance to travel in flowing through a granule the size of a filbert than in flowing through a granule the size of wheat. Moreover, because of its greater weight and longer churning, the surface of the larger granule is sealed to a greater extent than the surface of the smaller granule.

The smaller the granules, therefore, the more buttermilk can be washed out of them. If the granules are smaller than radish seed they drain so slowly that the method is impractical. I prefer granules the size of wheat.

Churning at a warm temperature will produce poorer results because butter comes so quickly that overchurning will often occur.

Before washing is completed the churn should not be turned unless the granules are floating on butter milk or water. Unless this foresight is used, the turning of the churn causes the mass of granules to fall with such impact that they are jammed together.

When the draining buttermilk flows a stream the size of the thumb the granules which have gently settled to the bottom in an open fluffy heap should be sprayed with water until the drainings (the bung is open all this time) become watery. The bung is then closed and water added to a depth of 6 to 12 inches. Whichever depth is chosen should be uniform from churning to churning. For 1000 pounds of butter about 100 gallons of water is required.

When sufficient water has been added the churn is revolved two or more turns in the slow gear. The water is drained through the bung and another dose of water added as before. The churn is again revolved in the slow gear or the butter is worked in the wash water, according to whether the buttermaker salts in the granular form or works his butter in the wash water. I prefer working in the wash water.

The history of the acidity of a churning was as follows:

1800 pounds of cream, fat 32¼ per cent

	PERCENTAGE	DEGREES MANNS'
Churning acidity	0.31	17.5
Acidity of buttermilk	0.47	26.0
Acidity rinse water (20 gallons)	0.24	13.3
First wash water (100 gallons)	0.17	9.3
Second wash water (100 gallons)	0.027	1.4
Acid of butter (AE)	0.14	
Size of granules	Wheat	
Butter produced (pounds)	716	

This is an actual and representative churning.

The decreasing acidity of the wash water indicates the removal of buttermilk and acidity from the butter. An acidity of wash water of 0.014 per cent (0.8 degree Manns') is as good as is practically possible.

It should be seriously borne in mind that large granules, say the size of filberts, very quickly yield wash water of low acidity. Large granules do not allow the water to enter and low acidity is due to slight removal or buttermilk.

An (AE) acidity of 0.14 per cent in the butter is average. The greater acidity in the butter than in the second wash water is due to the casein which is acid, as well as the fat which is also acid to the test here applied.

To make such copious washing practical it is necessary to provide convenient facilities therefor. The water is held at even temperature in a tank or vat provided with thermometer and regulators as desired. A three inch pipe line is installed behind the churns. A branch for each churn passes over the main churn bearing at the gear end. This terminates in a short length with two elbows, one of which is loose. This short length hangs down out of the way when not needed and swings to the left into the churn door when needed (see figs. 1 and 2).

To supply standardized amounts of wash water so the butter would be properly washed and brought to uniform hardness for

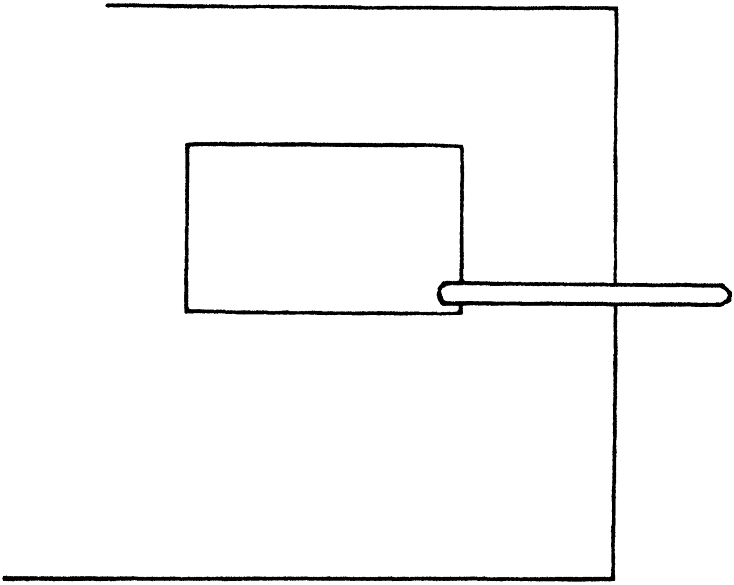

FIG. 1

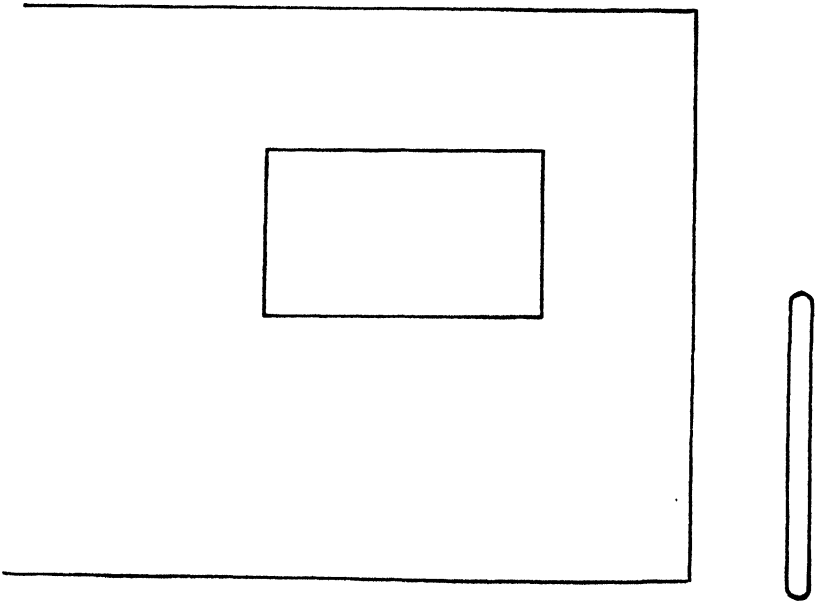

FIG. 2

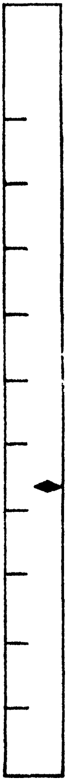

FIG. 3

working and controlling moisture, a float gauge, like on a railroad tank should be provided. By means of a cord this gauge can be placed so it could be seen from every churn (see fig. 3).

Given the acidity of cream, the acidity of buttermilk can be calculated. The acidity of buttermilk from cream containing 33⅓ per cent should be 50 per cent greater than the acidity of the cream. This is the acidity when neutralizing is properly done. In practice about one-half of centralized buttermilks tested shows a lower acidity than that calculated. About one-tenth of the buttermilks shows a lower acidity than the cream. This condition needs attention. When buttermilk has a lower acidity than cream, this is caused by improper neutralizing, namely, haste or lime of poor solubility.

A test of the acidity of butter takes longer and the reading is so small that only a very careful worker can make a reliable test. These objections do not apply to testing the acidity of fresh buttermilk.

By applying here the acid test which is one of the oldest and simplest tests one can ascertain whether the neutralizing was properly done. When one drop of formaldehyde per ounce of butter milk sample is added the sample may be sent to a laboratory to be tested for acidity at convenience.

A ROPY MILK ORGANISM ISOLATED FROM THE FINNISH "PIIMA" OR "FIILI"[1]

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Received for publication October 15, 1922

A bottle of milk, decidedly ropy in character, was brought to our laboratory by a Finnish student. It has not been possible to obtain a complete history of the beverage, but we were informed that some relative of a grocery man, who dispensed it, had sent to him through the mail from Finland, a culture absorbed in ordinary blotting paper. The beverage is known to these people as "Fiili" or "Piima." A search of the literature has failed to reveal any reference to this particular type of ropy milk. Inquiries made among investigators in this country have not yielded any information regarding it. Others have been consulted, among them editors of Finnish papers, but no scientific data was available.

An attempt was made to isolate the organism or group of organisms, responsible for the condition. A fresh twenty-four hour propogation was plated on "milk powder agar A" (Ayers and Mudge, Jour. Bact., v, 6, 565) with excellent results. After five days incubation at 20°C., besides a variety of organisms, there appeared colonies closely resembling the common Bact. lactis acidi colonies, which when penetrated by the platinum loop were found to be soft and viscid. As the loop was withdrawn, a threadlike attachment followed. This could be drawn several inches from the plate. Inoculations made from these colonies into sterile milk led to a decided ropiness of the milk after twelve to fifteen hours, both at 20 and 37°C., although more pronounced in the former.

The organism isolated in pure culture was studied in detail with the following results:

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[1] **Published with the approval of the Director as Paper No. 340, Journal Series, Minnesota Agricultural Experiment Station.**

MORPHOLOGY

Shape: Microscopically, the organism resembles the Streptococcus lacticus, occurring as small cocci, slightly longer than broad. In preparations from milk, bouillon, or agar, there was very little difference in the appearance of the organism.

Size: From twenty-four hour milk cultures, varied in size from 0.6 to 1.2 micron with the majority from 0.8 to 1 micron.

Arrangement: Occurred in pairs and in chains of from 4 to 20 individuals, the majority being between 6 and 10.

Capsules: Were not always evident but a thin capsule was noted in some cases when stained with carbol fuchsin.

Motility: None.

Spores: None.

Staining: Stained readily with the ordinary aniline stains. Strongly Gram positive.

CULTURAL

Plain agar: No growth.

Lactose agar plates: No growth.

Lactose agar stroke: No surface growth.

Lactose agar stab: Very slight growth along line of puncture, better near surface.

Milk powder agar plates: Colonies subsurface, white to cream colored, very viscid, bi-convex discs, about 1 mm. long by 0.25 mm. greatest diameter.

Milk powder agar stroke: Moderate, beaded, flat, smooth, whitish, to transparent, tenacious on surface. Viscid growth in water of condensation.

Milk powder agar stab: Slight growth along line of puncture, better near surface.

Plain gelatin plates: No growth.

Lactose gelatin plates: No growth.

Lactose gelatin stab: Slight growth at surface. Beaded along line of puncture. Better near surface. No liquefaction.

Plain nutrient bouillon: Clear. Slight sediment, slightly viscid on agitation.

PHYSIOLOGY

Glucose bouillon: No gas. Acid. Clear. Slightly viscid sediment.

Lactose bouillon: No gas. Acid. Slightly cloudy. Viscid sediment.

Saccharose bouillon: No gas. No acid. Clear. Slightly viscid sediment.

Maltose bouillon: No gas. Acid (strong). Cloudy. Viscid sediment.

Inulin bouillon: No gas. No acid. Clear. Slightly viscid sediment.

1 per cent aqueous solutions:

Glucose: Very slight acid. No ropiness.

Lactose: Acid. Slight ropiness.

Saccharose: No acid. No ropiness.

Maltose: Acid. Ropy.

Peptone (Bacto): Slightly acid. Ropy.

Egg albumin: Slightly acid. No ropiness.

Egg albumin and glucose: Slight acid. No ropiness.

Peptone and lactose: Acid. Slight ropiness.

Peptone and maltose: Acid. Ropy.

Plain skimmed milk: Slightly acid, not sufficient to coagulate. Few flakes of precipitated casein. Decidedly ropy after twelve hours. Best at 20°C. Ropiness persists. Slight amount of ropy serum arises after standing several days. Ropiness is uniform thruout tube. It was possible to pour the milk from a second story window to the ground (about 25 ft.) without breaking the rope. Even then the wind would form an arc of the thread which descended. Milk cultures retained their ropiness even after six months and when they had dried to nearly half their original volume.

Brom cresol purple milk: Moderately acid. Ropy. pH, about 6.4 to 6.5.

Plain whole milk: Acid. Ropiness not as pronounced as in skimmed milk.

Sour milk: No ropiness produced.

Whey: Acid. Ropy.

Casein (dialyzed): Neutral. Ropy.

Casein (dialyzed and maltose: Acid. Ropy.

Casein (dialyzed) and lactose: Slightly acid. Ropy.

Chromogenesis: None.

Temperature: Optimum 20°C. Grows well 12 to 37°C.

In milk cultures: After thirty minute at 60°C.—Produced ropiness. After thirty minutes at 65°C.—produced no ropiness. After one minute at 98°C.—produced no ropiness.

Moisture requirement: Cultures dried on blotting paper were capable of producing ropiness even after six months.

Oxygen requirement: Facultative.

Miscellaneous observation: Inoculations made into sterile milk from the sugar broth cultures, two months old, caused ropiness in all cases, but in addition, the milk was coagulated and pierced with gas voids, with the exception of the culture from lactose broth, which only produced slight acidity and ropiness. When sterile milk was inoculated from these milk tubes, ropiness appeared but no coagulation or gas. It appeared like an adjustment to environmental food supply.

DISCUSSION

Some of the interesting characteristics of the organism are its failure to grow well on the ordinary routine media, its ability to produce marked, persistent ropiness in milk, and its resistance to dessication and heat. It is able to produce the ropiness from certain carbohydrate or nitrogenous compounds separately or in combination as evidenced by its action on aqueous solutions of some of the sugars, particularly lactose and maltose and on the dialized, purified casein or peptone and mixtures of them. Albumen did not appear to be a suitable material for its formation. Consequently, the combination of the casein and lactose as it occurs in milk furnishes a most suitable medium for the action of the organism. The fat does not seem to be a factor, as whole milk did not become as markedly ropy as skimmed milk. This effect might have been physical.

The organism most closely resembles the Streptococcus lacticus var. Hollandicus comb. nov. (Hammer and Buchanna, 1915) and Streptococcus taette (Olsen-Sopp 1912), but inasmuch as the characteristics described differ from those which have been ascribed to the two above and others causing ropiness in milk, and as the literature as far as available contains no reference to "Fiili" or "Piima" or the causal agent, it is suggested that it be given as a new species—Streptococcus piima.

V. SODIUM HYPOCHLORITE[1]

SOME STUDIES ON THE BACTERICIDAL ACTION OF SODIUM HYPOCHLORITE IN COW'S MILK

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Received for publication January 10, 1923

If sodium hypochlorite possesses a phenol coefficient of such great magnitude and if it reverts into sodium chloride and oxygen upon decomposition, as it is generally claimed, the question naturally arises; why can it not be used with safety to sterilize milk?

There are many natural reasons outside of the Food and Drug Acts which preclude the possibility of its use in the above field, and we propose to discuss the natural reasons against its use, and to present new data bearing on the question. The more urgent is this investigation since sodium hypochlorite has become such a valuable disinfecting agent in food factories and dairies. In the hypochlorite disinfection of milking machines, pipe lines, pumps, vats and other utensils in the dairies and milk product factories, it is not always possible to drain the last traces of the dilute hypochlorite rinse from some of them. Consequently if fresh or pasteurized milk should be turned into or pumped through such apparatus, it will become contaminated with traces of the disinfectant. What will be the result?

In paper III of the hypochlorite series, one of us has taken up the question of the rate of destruction of NaOCl in cow's milk. The results from that study show that at constant temperatures quantities of NaOCl up to 0.02 per cent (available chlorine) are lost in the milk almost immediately without being detected in appearance, but may be detected by persons with sensitive palates. They also showed that the rate of destruction rapidly increased with temperature; also that the destruction of the NaOCl in the milk resulted in the chlorination of the casein and other proteins. There seemed to be no difference between the rate of destruction in raw, pasteurized or boiled milks which signified that, if there was any selective action on the sodium hypochlorite by the reductase present in the raw and pasteurized milk, the methods of examination were too crude to identify it.

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[1] **Read before a meeting of the Society of American Bacteriologists, at Detroit, Michigan, December, 1922.**

The results from that investigation, then, taught us that NaOCl actually loses chlorine to some of the constituents of milk, and that there was a limit to the quantity of the substance which would disappear in the milk in a given time. Traces may be lost entirely to the milk without detection. It remains therefore for us to determine what effect traces and excesses of sodium hypochlorite have on the bacterial flora in the milk.

METHODS OF STUDY

While these experiments are more or less preliminary, they are convincing enough for presentation.

Quantities of raw mixed market milk were obtained from the receiving station of a local milk plant on different days. These samples were divided into 1-liter portions and brought to the temperature of the experimental conditions. In two sets of experiments the temperature of sodium hypochlorite contact was 40°C. while in the others 20°C. was used.

After being brought to the observation temperature in a swift heat interchange water-bath, and immediately before the addition of the NaOCl, dilutions of the milk were made for plating, in order to determine plate count of the bacteria on the raw milk. The plating was done with milk powder agar described by us (1) in the October number of the Ice Cream Trade Journal. The milk powder agar would serve to give a qualitative aspect of any chance selective action of the hypochlorite on the lactic acid organisms and true peptonizers.

A 1 per cent solution of NaOCl served for the bactericide. Concentrations of NaOCl were added to the milk corresponding to an "available chlorine" content of 0.0001 to 0.1 per cent in the milk. Different periods of contact were tried for the purpose of determining the rapidity and permanency of the bactericidal action.

The results of these experiments are enumerated in table 1.

The pH of 0.01 per cent Av.Cl_2 milk was 6.8–6.9, while in case of the 0.1 per cent the pH lay between 7.1–7.2.

TABLE 1

	CONCENTRATION AV. Cl_2 ADDED TO MILK	TEMPERATURE	TIME CONTACT	PLATE COUNT	BACTERIAL DESTRUCTION	FREE NaOCl (?)
	per cent	°C.	*minutes*		*per cent*	
Set A	None	40	Zero	5,000,000	Zero	None
	0.01	40	10	3,045,000	39 1	None
	0.001	40	10	3,020,000	39.8	None
	0.0001	40	10	4,192,000	16.1	None
Set B	None	40	Zero	1,950,000	Zero	None
	0.1	40	5	687,500	64.8	Yes
	0.1	40	15	222,500	80.8	Yes
	0.01	40	5	1,422,500	27.0	None
	0.01	40	15	702,500	64.0	None
Set C	None	10	Zero	1,825,000	Zero	None
	None	40	Zero	1,642,500		None
	0.1	10	15	863,000	52.7	Yes
	0.1	20	15	660,000	64.0	Yes
	0.1	30	15	630,000	65.6	Yes
	0.1	40	15	605,000	68.0	Yes
Set D	None	20	Zero	2,350,000	Zero	None
	0.01	20	2.5	1,596,000	32.1	None
	0.01	20	10	1,330,000	43.4	None
	0.01	20	20	1,720,000	26.8	None
	0.01	20	30	1,542,000	34.3	None
	0.01	20	120	1,775,000	24.5	None

CONCLUSIONS

In regard to cow's milk, we can say that sodium hypochlorite has a relatively low bactericidal effect, in view of its vigorous bactericidal action on the bacterial cells themselves. Only when an excess of NaOCl was present (as indicated by starch sodium iodide test) did we consistently obtain more than 50 per cent reduction in the plate count; and then the highest obtained was 80.8 per cent. The milk is always a pinkish-yellow color in the presence of 0.1 per cent of added "available chlorine."

We can further say that the presence of the organic matter in the milk seems to protect the vitality of the organisms, as regards their power to reproduce on a milk agar plate, even after exposure to an excess of NaOCl in the milk.

This work is being continued to determine how much NaOCl and what time interval would be necessary to completely sterilize a given sample of milk, as revealed by the milk agar plate count.

A practical conclusion may be drawn here, viz., sodium hypochlorite solutions can only be used with satisfaction in a food factory as a rinsing solution, after the equipment is thoroughly washed. It must then be dilute and yet contain sufficient NaOCl to show the presence of available chlorine in the water after having passed over the last surfaces of the equipment.

THIONIN

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One of the infrequently used biological stains concerning which there has been so much confusion as to give trouble both to biologists and to the manufacturers and dealers supplying them with stains is thionin. A little discussion, therefore, of the uses for this stain and its synonymy seems worth while.

One of the first—perhaps *the* first—to introduce it into this country was Dr. M. P. Ravenel, then of the University of Pennsylvania. He learned to use the stain in Paris. Later going to Germany he was unable to get the desired results with the thionin found there and so he sent to France for the brand he had first used. He convinced himself that there were great differences between the thionins on the market. Returning to America he had the French dye imported from E. Cogit & Cie., of Paris.

A more recent use for this dye was suggested by Frost when he proposed his "little plate" technic for studying and counting bacteria in milk.[2] This technic was originally worked out by Dr. Frost with the French thionin imported for Dr. Ravenel. It seems to be for this purpose that there is at present the greatest demand for thionin and complaints have reached the committee from various sources that samples of a stain labeled thionin obtained in this country were not satisfactory, as they had the staining properties of the samples previously obtained from Germany instead of resembling the Cogit thionin.

An investigation of the synonymy of this stain shows what is the trouble. There are two distinctly different dyes which are often confused, one correctly called *thionin*, the other *thionin*

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[1] Chairman of Commission on the Standardization of Biological Stains.

[2] W. D. Frost, Improved technic for the micro or little plate method of counting bacteria in milk, Jour. Inf. Diseases, 1921, xxviii, 176–184. See also Standard Methods of Bacteriological Examination of Milk, 3rd, ed., 1921, p. 18.

blue. The former is synonymous with Lauth's violet, a name which seldom appears in the literature, however. Unfortunately, moreover, in Frost's paper describing the "little plate" technic he specified thionin blue instead of thionin. One other fact which adds to the conclusion is that the true thionin (syn. Lauth's violet) is no longer used in the textile trade and has not been listed in Schultz's Farbstofftabellen (the recognized index of the textile dyes) since the second edition. In the present edition thionin blue is listed, however; so it is quite natural that a manufacturer not familiar with thionin might supply thionin blue in its place.

Tests have shown plainly that for staining bacteria, especially in the Frost technic, thionin is required, not thionin blue; hence those ordering this stain are advised to specify "*thionin* (syn. *Lauth's violet*)." The only place in this country where we have found this stain available in the past is the Will Corporation at Rochester, who prepared a batch of it sometime ago not being able to find it elsewhere. At the present time, the Will Corporation stock being nearly exhausted, the National Anilin Company has prepared another lot to be put into circulation which will undoubtedly be available from general supply houses in the near future.

THE COLOSTRUM PROBLEM AND IT SOLUTION

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The colostrum problem as it concerns the dairyman arises in connection with the cow infected with tuberculosis or other serious disease whose progeny it is desired to raise. In such instances the newly born calf can not be allowed to nurse its mother in the natural way on account of the danger of infection. The problem is then what to feed the calf.

To solve this problem it is first necessary to get definite ideas concerning the properties of colostrum and concerning the function of colostrum in the regimen of the young calf. The following enumeration is intended to give these ideas:

1. First we will consider the quantitative chemical composition of colostrum as compared to milk. Differences in the quantitative composition with respect to the salt and fat content are not likely to be important. As far as the proteins are concerned, the differences in the concentration of casein and albumin in colostrum and milk is not very great. The concentration of casein is on the average the same in the two secretions, and the albumin content in colostrum is approximately twice that of normal milk. There is, however, an enormous difference between the globulin content of colostrum and of milk. Normal milk contains about 0.03 per cent of globulin, while colostrum contains 6 to 12 per cent globulin. This difference between milk and colostrum with respect to the globulin content seems to be very significant in view of the fact that the globulin of colostrum is identical with the globulin from blood serum, and that this is the only protein in colostrum or milk which is identical with a protein in blood (Crowther and Raistric, 1916; Wells and Osborne,

1921). The globulin seems to pass from the blood into the mammary gland unchanged.

2. A second fundamental difference between colostrum and milk relates to the immune body content. It is well known that after certain infectious diseases, for example typhoid fever in man, the blood is found to contain immune bodies, or antibodies, which serve to protect against reinfection. These bodies may be determined qualitatively and quantitatively by appropriate methods. Colostrum is known to be very rich in all types of immune bodies found in the blood of the mother animal (Famulener, 1912; Lane Claypon, 1916). The immune bodies like the globulin, seem to pass from the blood through the mammary glands unchanged.

3. A third significant fact is that the blood of the newly born calf contains neither globulin (Howe, 1921) nor immune bodies (Famulener, 1912; Little and Orcutt, 1922), neither are these substances found in the blood of the calf after a meal of normal milk. If, however, the newly born calf is given a meal of colostrum, and then the blood serum tested, it is found to contain both globulin and immune bodies. In other words, the globulin and immune bodies pass from the blood of the mother into the blood of the offspring unchanged in their passage through the mammary gland of the mother and through the alimentary tract of the young animal.

The globulin and immune bodies seem to travel together, and change together. If the globulin is separated from blood serum, it is found that practically all the immune bodies come down with the globulin fraction. During infectious diseases when the immune body content of blood rises, there is also a rise in globulin (Ledingham, 1907; for indirect evidence to the contrary see Schmidt, 1917). The concentration of immune bodies in colostrum is proportional to the concentration of globulin in colostrum (Staubli 1906; Famulener, 1912).

4. Clinical observations furnish a fourth significant fact. It is well known that breast fed children are less subject to infectious diseases such as diphtheria and measles, than are artificially fed children. Experience in our dairy herd shows this to be true with the calf. Calves that did not get colostrum were found

to be much more subject to many infectious diseases particularly scours and "enteritis" than the calves that received colostrum. The mortality of the calves which did not get colostrum was found to be much higher than of the calves which received colostrum.

From these four facts it appears that colostrum, or at any rate the globulin and immune bodies of colostrum, play a very important rôle in the regimen of the young animal. The immune bodies passing from the mother to the offspring by the way of colostrum, are of the passive, or transitory type. The concentration of these bodies in the blood of the young calf gradually diminishes; but while these passively transmitted immune bodies are diminishing, the young animal is gradually developing its own active defensive, or immune mechanism (Gewin, 1909; Ossimin, 1913). The benefits of colostrum while transitory, are evidently very important during the period of life when the animal is without its own defensive mechanism.

Since the distinctive feature of colostrum is its large globulin and immune body content, it seems clear that there is only one other substance that contains these, and that could therefore replace colostrum in part, and that is blood serum. Blood serum from a healthy cow if mixed with normal milk could undoubtedly replace colostrum; but this is hardly a practical method. Vaccines, or immune sera against the prevalent infectious diseases of the calf, such as anti-scour serum, could likewise in part replace colostrum. This in fact is recommended by Williams (quoted by Traum, 1921).

The ideal arrangement would be to disinfect the colostrum, so treat it as to inactivate the pathogenic organisms it may contain, but leave the immune bodies and globulin unchanged. Rapid freezing and thawing was found to fulfill this requirement. The passage of a high voltage current will probably accomplish the same end (Beattie and Lewis, 1913). These methods while simple enough to carry out in a chemical laboratory can not be recommended as a routine procedure to the dairyman.

A simpler method is offered by pasteurization. Those who previously have attempted to pasteurize colostrum, found that the colostrum coagulates into a solid cheese-like mass on heating and can not therefore be fed to the calf. On reinvestigating this subject it was found that those previously attempting to pasteurize colostrum used either a flame or steam as a source of heat. Now it was found that the temperature coefficient of heat coagulation of proteins is very high, and it rises with rise of temperature (Chick and Martin, 1910) and that therefore a difference of one or two degrees in the pasteurization temperature may determine success and failure in pasteurization. By the use of steam or a flame as a source of heat it is not possible to avoid local hot zones. The particles of protein that come in contact with the steam spray or hot bottom over the flame become overheated and coagulate, while the temperature of the colostrum as a whole may be below the pasteurization temperature. For this reason a water bath was used for heating the colostrum, and the steam was used to heat the water in the bath surrounding the colostrum container. The temperature of the bath as well as of the colostrum was carefully controlled by thermometers. With this precaution it was found to be entirely safe to pasteurize colostrum without the least danger of coagulating it. From what was said concerning the high temperature coefficient of heat coagulation of protein, and the rise of the temperature coefficient with the rise of temperature, it is clear that the lower the pasteurization temperature the greater the margin of safety. The following table showing the relative time required to thicken colostrum so it flows with difficulty when tipping the container, and the time required to inactivate the organisms of tuberculosis will further illustrate this idea.

TEMPERATURE		TIME REQUIRED TO INACTIVATE THE ORGANISM OF TUBERCULOSIS IN MILK	TIME REQUIRED TO THICKEN COLOSTRUM SO IT BARELY FLOWS
Degrees C	Degrees F.		
		minutes	
57.5	135.5		Over 14 hours
60.0	140.0	20.0	3 hours
62.5	144.5	18.5	30–40 minutes
65.0	149.0	14.0	10–15 minutes
67.5	153.5	7.5	4–5 minutes
70.0	158.0	3.0	2 minutes
72.5	162.5		70–75 seconds
75.0	167.0		45–50 seconds

The values in the table are only approximate, the exact values depending on the composition of the sample of colostrum. The composition of first milking samples of colostrum vary considerably, and the speed of heat coagulation is dependent on the concentration of the proteins, salts, and the hydrogen ions. The greater the concentration of these substances, the more rapid the thickening of the colostrum on heating. The effect of the hydrogen ions is particularly striking. The hydrogen ion concentration of colostrum is about pH 6.1 while that of normal milk is about 6.6. The coagulation time can be appreciably increased by bringing the pH of colostrum to that of normal milk by the addition of sodium bicarbonate, or milk of magnesia, or milk of lime. This is, however, not recommended as experiments showed that certain immune bodies in colostrum, particularly the amboceptors, are more thermostable at the natural reaction of colostrum than at the more alkaline reaction. It might be added that the effect of a number of other ions on the speed of heat coagulation of colostrum were studied following the ideas of Pauli (Pauli, 1903). The results do not, however, seem of sufficient significance to make their presentation worth while. From a study of the table presented above, it appears clear that it is perfectly safe to pasteurize colostrum at 140°F. and that it is not therefore necessary to add any substances to it.

Having determined that colostrum can be pasteurized without changing its physical properties, it becomes important to find out whether temperature affects its immunological properties. Experience would seem to indicate that pasteurized colostrum is in every respect as good as unpasteurized colostrum. Out of thirty-two calves in our herd that received pasteurized colostrum only two calves died—a mortality of 6 per cent. The others did as well in every respect as the calves which nursed in the natural way. Figure 1 shows growth curves of 5 experimental calves taken at random from the group. There is no constant difference in growth between the calves naturally fed, and the calves fed on pasteurized colostrum. On the other hand, out of 22 calves in our herd that received no colostrum, and fed on raw normal milk only, 7 died—a mortality of 32 per cent—results decidedly in disagreement with those published by other investigators (Buckley, 1920; Traum, 1921). These comparative mortality figures

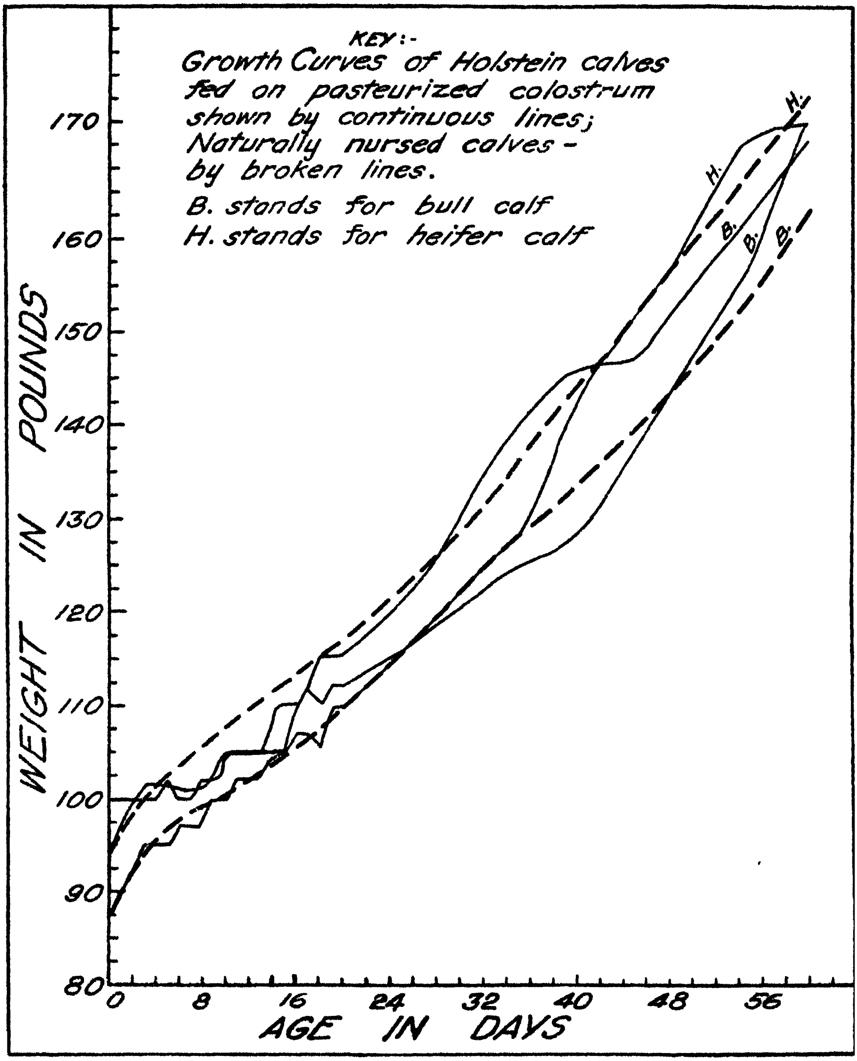

FIG. 1

show the efficacy of pasteurized colostrum and justify the conclusion that neither protein, nor immune bodies have been materially affected by pasteurization. These conclusions have been followed up by laboratory studies on some immune bodies. The amboceptor, or complement fixing, immune body was found not to be reduced appreciably in effectiveness by heating up to 149°F. for an hour. Above this temperature this body rapidly deteriorates. Of course the complement is destroyed at the pasteurization temperature, but this is not important inasmuch as the blood of the calf contains this substance. The effect of temperature on agglutinins in colostrum is more pronounced. Further quantitative data on the effect of temperature on these bodies will be reported some time in the future when more colostrum from reacting cows becomes available.

SUMMARY

1. The blood of the newly born calf contains no globulin or immune bodies. Colostrum is very rich in globulin and immune bodies. The globulin and immune bodies in colostrum pass into the blood of the newly born calf unchanged in the alimentary canal. These facts, and the further facts that disease and death rate is much higher among animals which do not receive colostrum than it is among those which do receive colostrum indicates that it is essential for newly born calves to get colostrum.

2. If the colostrum is infected with pathogenic organisms, these organisms may be inactivated by pasteurization. Pasteurization does not change the properties of colostrum to any appreciable extent provided the pasteurization is done in a water bath thereby avoiding local hot zones. On account of the relatively rapid rise of the temperature coefficient of heat-coagulation of proteins with rise of temperature, the lower pasteurization temperatures offer a wider margin of safety than the higher pasteurization temperatures; 140°F, is the safest temperature for pasteurizing colostrum.

3. Pasteurizing colostrum at 140°F. for twenty to thirty minutes does not appreciably change the properties of colostrum and experience shows that calves fed on such pasteurized colostrum get along in every respect as well as calves that are naturally fed, and very much better than calves which received no colostrum.

5. The satisfactory method to raise a calf from a cow infected with tuberculosis is therefore to separate the calf from its mother at birth, and feed the calf its mother's pasteurized colostrum during the first two to three days after birth. The colostrum should be pasteurized in a water bath at 145°F. for twenty minutes, or preferably at 140°F. for thirty minutes.

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A STUDY OF DETERMINING SOLIDS-NOT-FAT IN COW'S MILK

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With the advancement of dairy manufacturing more and more attention is paid to close approximations and efficient methods of analyzing the raw material--milk. In butter making the butterfat test of the raw material is of primary importance. In the manufacturing of cheese, ice-cream, condensed and powdered milks, the estimation of milk-solids-not-fat is also desirable and sought by the cheese and ice-cream manufacturers. The determination of butterfat is satisfactorily accomplished by the well accepted Babcock test as approved by the American Dairy Science Association (1).

In the estimation of solids-not-fat, however, no special direct standard method is employed but its calculations are made indirectly. 1. The total solids of a given sample are found by using the gravimetric method II (2).

2. The percentage of butterfat is subtracted from the percentage of total solids and the difference indicates the percentage of S. N. F. (solids-not-fat). Or, various formulas are employed which enable one to estimate the total solids and solids-not-fat to a great degree of accuracy for all practical purposes. Among the well known formulas the following may be mentioned: Fleischmann's (3), Richmond's (4), Hehner and Richmond's (5), Ambuhl's (6) and Babcock's (7).

PURPOSE

The main purpose of this study is to find a formula which could be considered as a standard and deduct a workable coefficient

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[1] Published by permission of the Director.

which will facilitate close approximations when using this formula as compared with gravimetric determinations. To accomplish this end the writer made use of the data compiled by R. H. Shaw

TABLE 1

Average specific gravity, nitrogen, sugar, fat and solids not fat for each cow, each breed and the total average

NUMBER OF COW	BREED	NUMBER OF CASES	SP. GR. QUEVENNE DEGREES	TOTAL N.	SUGAR LACTOSE	B. FAT	S. N. F. GRAVIMETRIC METHOD	S. N. F. BABCOCK METHOD	G/B COEFFICIENT
				per cent	*per cent*	*per cent*	*per cent*	*per cent*	
4	J.	25	33.4	0.61	4.79	4.88	9.31	9.23	0.9978.
99	J.	37	32.9	0.53	4.99	4.70	8.95	9 17	0.9760.
118	J.	33	34.2	0.65	4.87	5.39	9.66	9 63	1.003
Average for Jerseys			33.5	0.60	4.88	4.99	9.31	9.38	0 9925.
205	H.	47	32.9	0.47	5.09	3.23	8.76	8.87	0.9875
206	H.	40	29.8	0.44	4.25	2.96	7.98	8.04	0.9925
209	H.	46	31.4	0.52	4.29	3.09	8.42	8.45	0.9964
Average for Holsteins............			31.4	0.48	4.54	3.09	8.39	8.46	0.9917
300	A.	26	33.3	0.60	4.86	4.20	9.23	9 18	1.0054
300	A.	24	31.8	0.48	4.84	3.49	8.56	8.62	0.9918
301	A.	25	33.1	0.54	5.02	4.28	9.11	9.13	0.9978
301	A.	37	32.6	0.51	5.00	.3 84	8.88	8.93	0.9944
302	A.	12	31.7	0.55	4.78	4.47	8.77	8.85	0.9909
Average for Ayrshires........ . ..			32.5	0.54	4.90	4.05	8.90	8.94	0.9955
400	MS	35	33.9	0.53	5.09	3.86	9.22	9.26	0.9956
402	MS	29	33.8	0.54	4.97	4.04	9.16	9.24	0.9913
403	MS	14	33.2	0.49	5.23	3.34	8.78	8.97	0.9788
Average for milking Shorthorns........			33.6	0.52	5.10	3.75	9.05	9.15	0.9890
Total average			32.8	0.54	4.86	3.97	8.92	8.99	0.9922

and C. H. Eckles (8). In their works a 'comparison of 430 determinations for T. S. in cow's milk, both gravimetrically and by the use of several formulas were cited and Babcock's formula proved to be the most efficient one. This conclusion based upon exhaustive numbers of samples makes it possible to consider Babcock's formula for the determination of solids-not-fat in cow's milk (9), as a standard. Furthermore, a comparison of 430 determinations of solids-not-fat in cow's milk, both by the analytical chemical method and according to Babcock's formula is a reliable basis for calculating the coefficient of variability which is to be used in determining solids-not-fat of normal milks in connection with the application of Babcock's formula, S N. F. equals $\frac{L}{4}$ plus0.2 f (L = Lactometer reading in Quevenne degrees, and f equals percentage of butterfat).

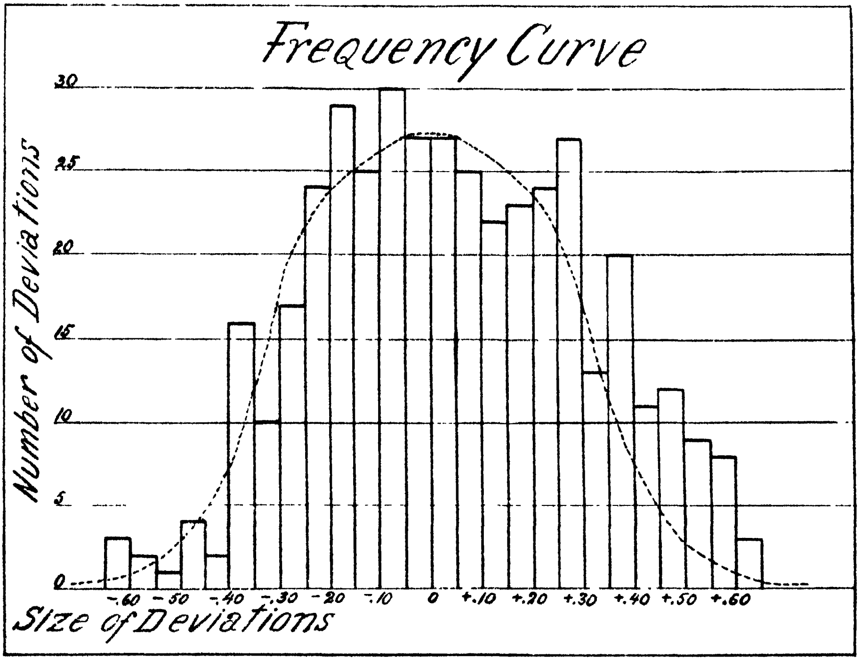

Table 1 shows that the average for the Jersey milk has been computed from 95 determinations, for Holstein-Friesian milk from 133 determinations, for Ayrshire milk from 124 determinations, and for Milking Shorthorns the averages are based on 78 determinations. The total average is the mean of the breed averages obtained through a total of 430 determinations. The G/B coefficient is the quotient of the percentage of solids-not-fat obtained by the gravimetric method and the percentage of solids-not-fat for the same samples computed according to Babcock's formula.

The diagram presented here exhibits the close approximation of the deviations when compared with the hypothetical curve based upon the law of probabilities (10). The mean deviation of the determinations made by the application of Babcock's formula from the corresponding determinations derived by the use of the gravimetric method is plus 0.0604.

CONCLUSIONS

A study of the data obtained by R. H. Shaw and C. H. Eckles reveals the fact that in estimating solids-not-fat by the use of Babcock's formula the following points should be considered:

1. The coefficients of variability in determining solids-not-fat in normal cow's milk by the use of Babcock's formula are as follows:

0.9925 for average Jersey milk;
0.9917 for average Holstein Friesian milk;
0.9955 for average Ayrshire milk;
0.9890 for average Shorthorn milk:
and 0.9922 for average mixed milk of all breeds.

2. Comparing results calculated by the use of Babcock's formula with those obtained gravimetrically the mean deviation is found to be plus 0.0604.

3. To come within very close approximation to the chemically determined value for solids-not-fat in normal cow's milk the following formulas should be used:

(a) S. N. F. equal ($\frac{L}{4}$ plus 0.2 f.) $\times$ 0.9922.
or (b) S. N. F. equal ($\frac{L}{4}$ plus 0.2 f.) $-$ 0.0604.

I am greatly indebted to the United States Department of Agriculture, Bureau of Animal Industry for the available data contained in Bulletin 134.

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NOTEWORTHY EVENTS IN THE WORLD'S DAIRY INDUSTRY 1922

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The beginning of 1922 found the United Kingdom the greatest dairy market in the world with a surplus quantity of products on hand which had been purchased by the government. These supplies were disposed of early in the year and the effect of government control was removed and the natural law of supply and demand again became a factor in the trend of production, prices and distribution of the world's dairy products.

During the first ten months of the year, the United Kingdom continued to import increased quantities of butter, but for the first time since the war began, imports of cheese decreased. This indicated an increased demand for butter and a slackened demand for cheese in the world market.

CHANGES IN THE SOUTHERN HEMISPHERE

The industry of Argentina closed a very bad year last May, having suffered from drought and loss of cattle which reduced the exports of dairy products about one-third.

The Government of Australia, feeling the necessity of improving the quality of her exported dairy products, issued regulations prohibiting exports of butter and cheese unless it had been graded and branded by regularly appointed officials of the commonwealth. Five grades of butter were established, as follows:

1. Choice
2. First grade
3. Second grade
4. Third grade
5. Pastry

One outstanding change in the New Zealand dairy industry noted during the year was the lengthening of its production season. Usually the season has opened in October and closed in May, but it is being lengthened to reach even to July or later. This lengthening of the season has considerable effect upon world trade conditions at the beginning of the production season in the Northern Hemisphere.

The improved quality of product and important position of New Zealand in the English market is noteworthy. New Zealand butter is now generally quoted as high as the Danish, and the New Zealand cheese outranked the Canadian to such an extent that the Canadian cheese could not get proper consideration on the London market until the New Zealand cheese stocks had practically disappeared.

Another important factor in the New Zealand dairy industry is the type of their factories. Their factories are equipped to make butter or cheese as desired. If the market becomes loaded with one product they can turn immediately to the other product and thus supply the most favorable market. The smallness of the country and the existence of coöperative organizations make possible concerted action for the whole country. A bill was recently introduced in the legislature in New Zealand to control dairy exports and place the matter of contracts under a special committee. While this bill has not been reported as passed it shows the trend of sentiment on the marketing problem in that country.

TRENDS IN THE NORTHERN HEMISPHERE

During 1922 Denmark has sought to become less dependent upon butter as a principal dairy export product. Accordingly without neglecting its butter trade it has built up a cheese trade, since the war, principally with Germany, with grades and government inspection. It has also put condensed milk on its list of export products.

Conditions prevailing in the Netherlands during 1921 continued into 1922. Butter and cheese production were low on account of inability to meet the competition from New Zealand, Australia, Argentina and Denmark in foreign markets. The milk was turned largely into condensed milk and by-products. In the first nine months of 1922 the Netherlands imported 9,013,476 pounds of butter from these countries, principally Australia and New Zealand. It is claimed that this unusual condition was due to the difference in exchange between the Netherlands and the countries usually buying her dairy products.

France removed the import tariff on butter in April and since that time has received an increasing import of unsalted butter, largely from Australia, New Zealand and Argentina, with a small amount from Denmark.

A notable event in Canada was the passing of an amendment to the Dairymen's Act of Alberta. This bill did away with cream buying stations and provided for Government inspection. The purpose of this Act was to raise the quality of butter made, by preventing the use of old, stale cream. In 1917 more than 50 per cent of the butter graded in Alberta was passed as special grade. By 1920 this quality had decreased until there was only 7.7 per cent of the special grade. The butter makers and the factories no doubt were as nearly perfect in efficiency in 1920 as they were in 1917 and the decrease in quality was due to the poor condition of the cream received.

In the United States one of the most significant factors in dairying was the large increase in consumption of butter and whole milk reported last year and a further increased consumption this year. The manufacture of sweet cream butter has also increased very rapidly during the year. This is rather a new departure in butter manufacture, for heretofore the demand has been chiefly for a product showing a mild to high lactic acid flavor and aroma. As sweet cream butter production increases, its merits will become better known. Sweet cream butter is now made in many creameries that formerly produced butter from sour cream. It is recognized as having a creamier flavor and better keeping quality.

SUMMARY OF 1922 TRENDS

Canada, New Zealand, Denmark, Australia and the United States have stressed the importance of quality, especially in butter. New Zealand butter ranks today on the English market with the best Danish. The greatest cheese exporting country now is New Zeland. Denmark holds her position on the butter market by the excellency of her butter and has endeavored to produce more cheese and condensed milk for export. It has also inaugurated an inspection service for export cheese which will guarantee its quality. The dairy industry of the Netherlands would have suffered greatly, or at least temporarily in 1922, but for the fact that her factories could make other kinds of dairy products besides butter.

The significance of these efforts toward excellency of quality of butter is not without a reason. The public is becoming more and more exacting in its demand for good butter. Development of sweet cream buttermaking in the United States is designed to meet this demand which is growing rapidly.

The advantage of having factories equipped so that they can make any kind of dairy products and can change from one product to another is great. Especially is this true in small countries where the industry is thoroughly organized and is largely dependent upon export markets.

In a word, the principal events of the year indicate progress in three lines: Better quality of products; closer grading and inspection; more complete organization making possible adjustment of production to market demands. Whenever any of the principal dairy countries develops a more complete factory organization for manufacture of dairy products, classifies and grades its products more closely and utilizes to a greater extent its geographical, seasonal, climatic, or other natural condition, in the development of its industry it immediately becomes incumbent on all other dairy countries to follow with equal progress if they would maintain their position in the world's dairy markets.

REVIEW OF FOREIGN DAIRY LITERATURE

R. C. FISHER

Storrs, Connecticut

Van Dam W. and Sirks, H. A., Proef Zuivel Boerdery to Hoorn-Netherlands. Studies in Regard to Body and Consistency of Butter in the Netherlands.

1. The object of our investigations was to ascertain the varying degree in which creamfats from the different provinces of the Netherlands at different seasons of the year are subject to crystallization, this varying liability to crystallization being one of the most important factors determining the body of butter made from the cream. The degree of the tendency to crystallize was determined and numerically expressed by the application of the dilatometric method described in an earlier paper.[1] The amount of the expansion of 45 per cent creams on heating from 13° to 28°C. after cooling to 12°C. for twenty-one hours, was taken as a measure of the firmness to be expected in the butters made from them by faultless methods of manufacturing.

2. Every two weeks we examined the creams from twenty dairies, selected in such a way as to cause the influence of different circumstances in the production, as food, treatment, soil, etc., to come out as clearly as possible. We selected 4 dairies in Friesland, 2 dairies in North Holland, 2 dairies in Drente, 3 dairies in Gelderland, 2 dairies in Overijsel, 4 dairies in Brabant and 3 dairies in Limburg. The experiments were made in the summer of 1918 and in the stall-feeding season 1919–1920.

Besides the numbers given above for the expansion of the cream we determined those for iodine, the volatile acids (R.M.) and the refraction at 40°C. of the butterfat.

3. The figures obtained were noted down in the tables 1 to 20 (Annual Report for the year 1921) and graphically represented in curves. The following table and graph shows the combined average from all the dairies from which samples were obtained in the different parts of the Netherlands:

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[1] cf. Verslagen van Landbouwkundige Onderzoekingen der Rijkslandbouwprœfstations 16.1 (1915).

Table showing the average fat constants of butterfat in cream from 20 dairies in the Netherlands during different seasons of the year

	EXPANSION	IODINE NUMBER	REFRACTION NUMBER	R. M. NUMBER
April 29	146.4	40.2	44.2	30.8
May 13	137.0	41.9	44.6	30.5
May 27	143.7	40.8	44.3	30.6
June 10	149.6	39.4	43.9	30.3
June 24	154.1	40.0	44.1	29.8
July 8	150.8	40.8	44.3	29.6
July 22	145.0	42.9	44.9	28.7
August 5	142.1	43.9	45.0	28.4
August 19	140.0	43.4	45.2	27.9
September 2	138.4	43.7	45.3	27.6
September 16	139.1	43.8	45.4	26.9
September 30	138.7	43.8	45.2	26.9
October 14	143.4	42.6	44.9	26.7
October 28	157.1	39.3	44.2	27.4
November 11	170.9	36.3	43.3	28.4
November 24	182.0	33.5	42.8	28.8
December 8	179.3	33.9	42.9	28.8
December 19	174.9	34.8	42.8	29.2
January 5	172.2	34.8	42.9	29.0
January 19	170.9	34.9	43.1	29.6
February 2	170.3	34.6	43.1	29.0
February 16	167.3	34.9	43.3	30.3
March 1	166.5	35.7	43.3	31.0
March 15	167.9	34.7	43.2	31.2
March 29	166.1	35.3	43.3	31.3
April 12	161.2	37.2	43.5	30.8

Those obtained for the expansion are on the whole in harmony with what has been found to be the case in practice, weak-bodied butter being produced in the summer months and butter with a firm body in the winter, also when the influence of temperature is excluded. In the pasturing season small numbers were found for the expansion, in the stall-feeding season the numbers were great and this was found to hold for all the dairies. Further, our experiments on this large scale confirmed what we found in our earlier research,[1] viz., that the numbers for the expansion are approximately correlated to those for the iodine, great expansion numbers answering on the whole to small iodine-numbers and vice versa. As for the R. M. numbers we found former results confirmed, the numbers for autumn being higher in the southern provinces than in the northern provinces. It should be observed that there was much less regularity with regard to these numbers in the case of each particular dairy than there was in the other constants.

4. On closely examining the curves we found the results of practical experience during the summer season confirmed by our figures. The

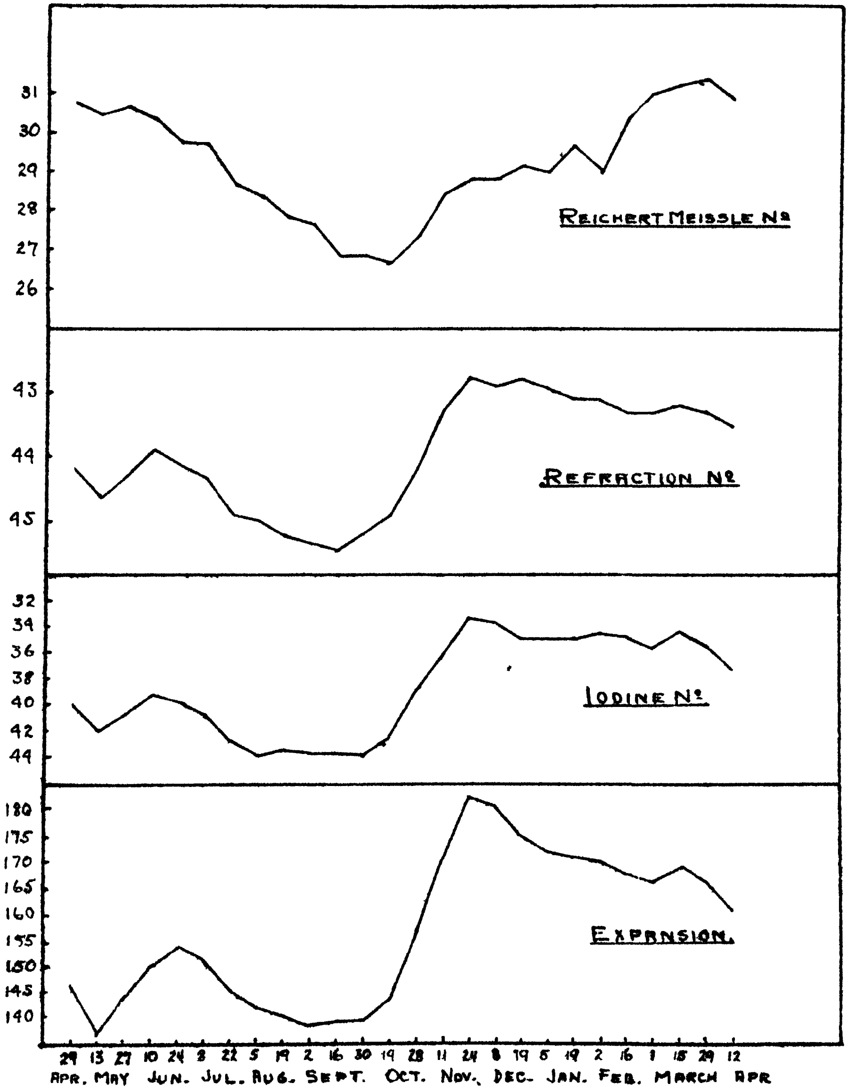

Chart 1. Showing the Average Fat Constants of Butterfat in Cream From 20 Dairies in the Netherlands During Different Seasons of the Year

production of a very weak-bodied butter during the first few weeks of pasturing, of more solid butter in June and July and of softer butter again in autumn was very correctly expressed by the expansion curves, as shown in the following table:

*Table showing amount of expansion of tendency to crystallize of 45 per cent cream during the pasturing or summer season**

PROVINCE IN WHICH CREAMERY IS LOCATED		AMOUNT OF EXPANSION								NUMBER OF SAMPLES	
		125–130	130–135	135–140	140–145	145–150	150–155	155–160	160–165	Below 140	Above 150
Noordbrabant	1. ...	0	1	4	6	2	0	0	0	5	0
	2.	0	0	0	4	3	3	1	1	0	5
	3. ..	0	0	2	8	1	1	1	0	2	2
	4. ..	0	0	1	2	5	3	1	1	1	5
Limburg	1 .	0	0	4	4	1	1	1	1	4	3
	2	00	0	3	4	2	2	1	0	3	3
	3.	1	0	0	6	4	2	0	0	1	2
Gelderland	1	0	0	4	2	4	2	0	0	4	2
	2...	0	2	3	2	4	0	0	0	5	0
	3 ...	1	4	4	1	2	1	0	0	9	1
Overijssel	1. .	0	0	4	4	0	3	1	0	4	4
	2. ..	0	4	3	2	2	1	0	0	7	1
Friesland	1. ..	0	0	2	3	4	0	3	0	2	3
	2. ...	0	0	5	2	1	3	1	0	5	4
	3...	0	0	4	1	3	1	2	0	4	3
	4. ..	0	0	0	2	5	2	3	0	0	5
Noordholland	1. .	0	4	2	3	0	3	0	0	6	3
	2. ..	0	1	6	1	0	1	3	0	7	4
Drenthe	1. ...	0	1	4	3	3	1	0	0	5	1
Total..............		2	17	55	60	46	30	18	3	74	51
		32 per cent Too low to make a sufficiently firm-bodied butter					22 per cent Such as to insure a good bodied butter				

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* The amount of expansion of 45 per cent cream when heated from 13 to 38°C, after cooling to 12°C. for twenty-one hours was used as a means of measuring the firmness to be expected in the butter made from such cream.

The composition of 32 per cent of 231 samples examined in the summer season was found to be such as to exclude the possibility of producing a sufficiently firm-bodied butter from their fat. That of 22 per cent was such as to ensure the production of good butter. That of 46 per cent was found to be such as to render a good degree of hardness in the butter somewhat less likely than a not quite satisfactory one.

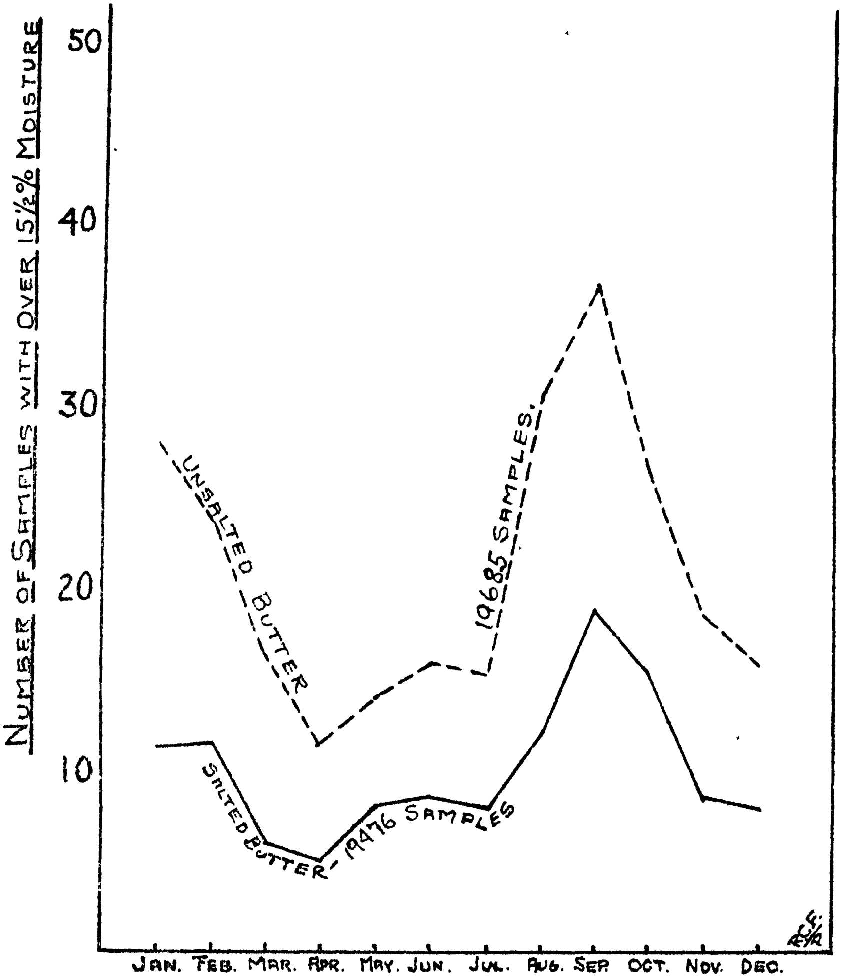

CHART 2. RELATION BETWEEN THE NUMBER OF SAMPLES OF BUTTER WITH MOISTURE CONTENT OVER 15.5 PER CENT AND THE SEASON OF THE YEAR

Analysis covers six year period in Netherlands

In those cases in which very distinct differences were observed in the expansion of creams got from different dairies in one and the same province, our numbers were found to tally almost exactly with the figures of the butter tests in that province.

5. We have also tried to account for the appearance of distinct maxima and minima in the curves of all the dairies in June and July and in autumn respectively with regard to the tendency to crystallize. The appearance of these maxima and minima tallies with practical experience as regards the body of the butter. Starting from the assumption that the composition of the butterfat is predominantly influenced by the qualities of the food eaten by the cattle we tried to establish how far these maxima and minima may be attributed to changes in the composition of the grass as consumed by the cattle in the summer.

*Table showing analysis of autumn meadow grass**

	CRUDE PROTEIN	DIGESTIBLE PURE PROTEIN	FIBRE	CARBOHYDRATES
Mowed grass, October 21, 1915	18.0	10.7		
Mowed grass September 26, 1916	14.0	8.1	27.0	43.3
Mowed grass, October 12, 1917	17.2	9.6	25.0	38.2
Picked grass, September 9 to December 2, 1916	18.6	11.6	18.9	46.0
Mowed grass, November 1916	17.0		25.3	
Average for grass	17.0	10.0	24.0	42.5
Hay, 1906	10.6	4.0	35.2	43.1
Hay, 1909	11.9	4.8	33.4	40.6
Hay, 1909	12.4	6.8	34.0	40.8
Hay, 1909	9.0	4.1	36.7	43.2
Hay, 1916	11.3	5.5	33.7	42.6
Hay, 1920	16.4	7.1	32.6	39.2
Hay, 1920	9.5	5.2	31.5	47.2
Average for hay	11.6	5.5	33.9	42.4

* From unpublished analyses of the late Dr. Ott De Vries, Hoorn Experiment Station.

These analyses of autumn meadow-grass prove, that to the great difference of the composition of hay and of such grass the slightness of the crystallization in autmn may be due. The analyses show that in the months of September, October and November the cattle receive far too much nitrogenous matter and far too little cellulose. That the butter becomes considerably less soft towards July is in accordance with our assumption, the bunches of grass eaten by the cattle being then in an advanced state of growth and there being less albumen and more cellulose in them than in new grass. We think that researches

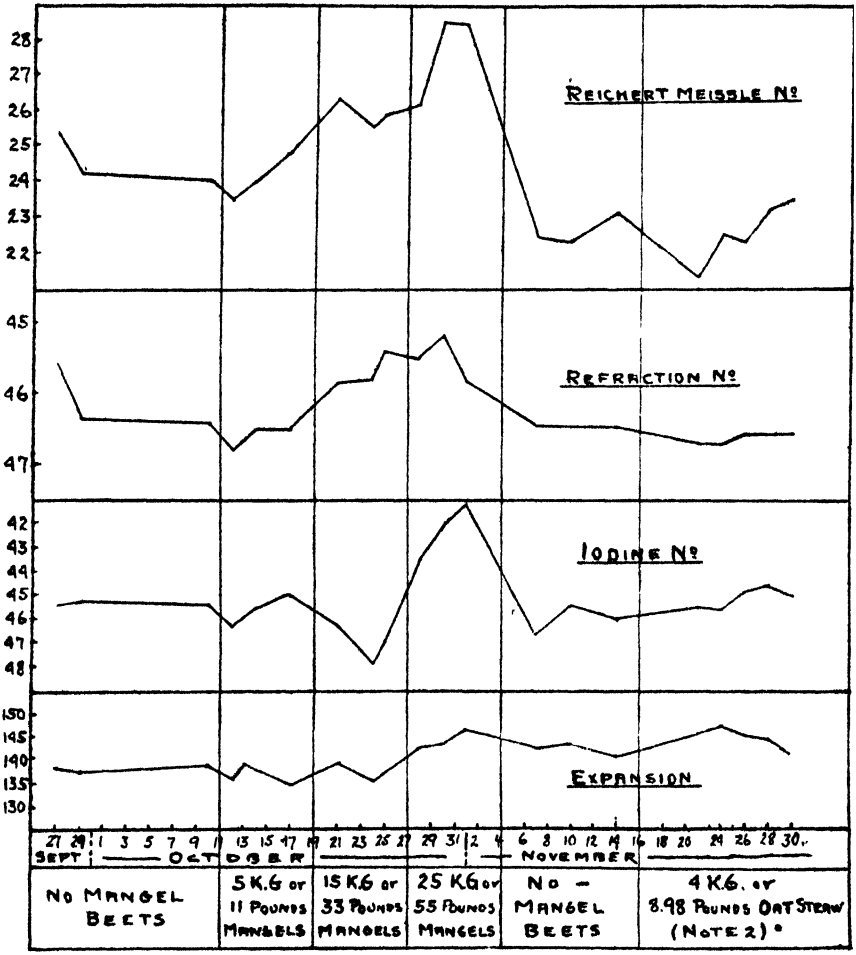

Chart 3. Showing Influence of Feeding Mangel Beets and Oat Straw on R. M. No., Refraction No., Iodine No. and Expansion No. of Butterfat

Cows on grass

* Pasture was changed on November 26, as there was more grass in this pasture, the straw was not relished as well and in some cases not eaten at all.

on an extensive scale concerning the composition of fresh grass as consumed by the cattle at different times in the pasturing season would be of the highest value with a view to the solution of this problem of the changes in the consistency of Dutch butter.

6. The above mentioned maxima of expansion in June and July which were observed in the creamfats of almost all the dairies, correspond in a remarkable degree with the numbers for the moisture content of the butter at this season, as determined by the butter control stations, Meyeringh[2] examined the moisture numbers of 19476 samples of salted butter and 19685 samples of unsalted butter and established the number of cases in the different months of the year in which the butter contained a high percentage of water, 15½ per cent or over. His figures refer to a course of six years.

In Meyeringh's curves our maximum for the expansion in the summer appears in the form of a marked decrease of the number of samples with a high moisture content, the correspondence with our results being very striking. This shows very clearly the correlation between the percentage of moisture in the butter and the composition of the cream fat.

7. Finally we have tried to improve the body of the butter in autumn by the addition of mangels to the food.

The favorable influence, though clearly observable in the expansion of the cream on adding 25 K. G. per cow, was by no means so strong as might have been expected from the changes in the iodine number and the refraction. It appeared that a number of 10 cows is too small for an experimenter to obtain reliable results in this kind of research.

A tentative experiment made under very unfavorable conditions brought out that the addition to the food of cellulose in the form of oatstraw may perhaps somewhat improve the autumn butter. We intend to make this experiment once more with a larger number of cows and under more favorable conditions.

[2] Diss. Delft 1911.

EXTENSION ACTIVITIES AND THEIR RELATION TO THE COLLEGE AND THE EXPERIMENT STATION

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There appears to be a wide diversity in the relation of the extension service to the college of agriculture and the experiment station in different states throughout the union. In some institutions the authority is decentralized so that the duties of the dean of the college of agriculture, the director of the experiment station, and the director of the extension service are vested in as many different persons. Likewise supervision of the resident instruction and the experimental work in dairying is divorced to a considerable extent from that of the dairy extension activities, although in practically all cases the teaching of the extension work is expected to be in accord with that of the resident instruction.

In other states the authority is centralized and the dean of the college of agriculture is the director of the experiment station and also the director of the extension service. He may be assisted by a vice-dean of the college of agriculture, an assistant director of the experiment station and an assistant director of the extension service. Where the authority is thus centralized the head of the dairy husbandry department is responsible for the teaching, the investigation and the extension work in dairying, so that the department is the unit for these various lines of activity. The head of the department makes recommendation for the appointment not only of instructors and investigators but also of extension specialists. The latter are attached to the various departments in exactly the same way as teachers and investigators. The head of the department supervises the planning of the extension work, keeps the extension workers in touch with the research work and has general control except for administrative matters such as finances and the itinerary of the men. Between these two forms of organization there are a considerable number of combinations.

Which of these types of organization is best or whether any one type is best is difficult to say. Each plan seems to be working well in the particular States where it is in use although some members of the staff in certain States have stated frankly that they believe a different form than that now in use in their State would be an improvement. I shall bring to your attention some of the thoughts that have been expressed concerning the advantages of the various forms of organization and I trust that the consideration of the whole subject will be helpful in enabling us to render the best possible service to the people of our respective States.

Those who favor a separate organization for carrying on the agricultural extension work of the state, wherein the different lines of activities such as dairy husbandry, animal husbandry, agronomy, and horticulture are headed by extension specialists, responsible to the head of the resident instructional and experimental work only in that the teaching in the field is to be in accord with that of the department, feel that the departmental head who already is dividing his time between teaching and research cannot advantageously divide his time and effort still further in order to give attention to a line of work that is different and distinct from those already under his direction.

Furthermore, the director of extension should feel the responsibility for seeing that the maximum amount of work is performed by the specialists in the different lines, and on their part the specialists will take a greater interest in their work and will be likely to get better results if they plan and direct the work and are held responsible for it than if some one less closely associated with the work directed it.

If the animal husbandman, the dairyman and the agronomist had the direction of the specialists in these lines, the extension director might find difficulty in accomplishing the special things he has in mind. They might differ in their opinion as to what lines of work should receive increased attention. A particularly ambitious man in one line of work might want most of the funds available put into his projects.

The resident teaching staff is not able to keep so closely in touch with the problems of the field as the extension specialists themselves. The latter consequently are in better position to plan and put across a strong program of work in the field than are the resident instructors.

As one director puts it:

> Extension work must be projected in a community, county, or in the state, with a definite program, based on the agricultural needs of the community, county or state, and adapted to the local agricultural needs and home life of the community. In other words, this program must get closer to the needs of the respective communities of the State. In developing this program, the farm and farm home must be considered more and more as a unit, and the various lines of work so correlated as to make the farming and home life of these farms more profitable. Therefore, each line of work must have its proper place in the farm management scheme of the individual farm or the social and economic welfare of the community. In times past extension work has been largely projected by individual demonstrations in dairying, livestock, fruit growing, potato growing, etc., said demonstrations being conducted on farms and in communities, without any relation to each other. This form of demonstration work while it was helpful and a necessary step in the development of extension work that would have to be undergone to bring extension work to its present level, has profitably served its purpose: But the time has come when the farm must become the demonstration unit, and these varied lines of work correlated into a farm management program for the particular farm or community. For example, assuming that we were going to develop beef cattle production in a certain community or on a certain farm, this would naturally appear to be an animal husbandry project. However, there must be forage and feed crops for these cattle, and the agronomist must assist in developing the program. It would be hard to say which is the more important: the animal husbandman or the agronomist—both are equally essential. Then, there may be a marketing problem which involves the help of a marketing specialist, and so on with other specialists which would enter into the development of this particular program.
>
> Now, the extension director can visualize the program in a community or county, and correlate these various lines far better than the head of a departmental unit. Furthermore, it is a whole lot easier to correlate a group of specialists who are responsible to one head than it is for a

superintendent of extension to correlate the work of heads of departments who are not responsible to him, but rather are responsible to the dean of the college of agriculture or the director of the experiment station. Furthermore, the head of a departmental unit is by the very nature of the work largely interested in his particular subject and unconsciously is bound many times to be onesided and look at things with this kind of viewpoint. Often he is not thinking in terms of an agricultural program as a whole, but rather a part of it, and there is the possibility that due to his interest in his own particular line of work and his desire to see it developed, he may sell to a community or county something which they ought not to have, and which really does not fit into the community or county program. We have this happen periodically with specialists who are over-zealous in their work; they get out in counties and attempt to put over some particular piece of work for which the county or community is not specifically adapted, but which the people can readily be talked into wanting. Of course, such a project fails.

Then, too, many of the heads of our departmental units are research men or resident teaching men, whose work has kept them closely at the college or experiment station, with the result that they have not been out over the state much and do not know either the people or the agricultural needs of the state nearly so well as some head of an extension division whose business it is to be in touch with the people of the State and to be informed by personal contact with the agricultural needs of the various sections of the state, counties, and communities. It is my firm belief that no head of a department, either a research man or a resident teaching man, can develop a state-wide, constructive policy along his line of work unless he has had an opportunity for traveling the state and knows the practical needs of the various counties and communities. Therefore, his programs are not going to be as close to the people as we think necessary to make them practical. Extension work must get closer to the real needs of the people. This not only means that the subject matter presented to them must be more practical and adapted to their immediate needs, but also that the contacts must be closer and particularly the contacts of those who form the developmental policies of the respective lines of work carried on in various counties over the state.

Those who believe that the various departments of the college should have the three functions: teaching, research and extension, and that the purely administrative matters such as the making up of schedules, the supervision of financial matters and the arrangement of conferences should properly be handled by the extension director base their claims on the fact that such a plan brings the workers of all phases of a certain activity together under one leadership which makes unity of teaching, promotes harmony and eliminates many of the problems of competition.

This arrangement keeps the extension men in close touch with the work that is being done in the department and keeps those in resident work in close touch with what is being done throughout the state. Neither has to depend on occasional conferences since by officing and working together they are constantly in touch with one another. An important part of the extension man's work is to carry out to the people on the farm the results of investigations in the department. This can better be done by having the extension specialist a member of the department rather than of a separate organization.

One director states:

> This institution has taken the position that resident teaching, extension teaching, and experiment station work are all phases of the same large problem, that of agricultural betterment. We have been inclined to believe that it is wise to have the college and experiment station staff in actual contact with the people of the state and their problems, and for this reason we have not been inclined to build up a large and independent body of extension specialists. We have, of course, had a few, but our feeling now is that even those, in most instances, should have a definite college and experiment station connection.
>
> The idea that the extension specialists can carry out, second hand, the so-called "bottled information" of the college and experiment station to the people and bring back and turn over, second hand, the problems which should be investigated by experiment station workers may be right in theory, but in practice it works out decidedly to the disadvantage of the college and experiment station workers who are, after all, and must always remain, the substantial sources of information for extension teaching.

With all these facts in mind, we are, as far as practicable, asking our heads of departments to be responsible for resident teaching, for extension teaching and for investigation.

Another director adds this comment:

> We have here only one and not three departments for any one subject. The plan has worked exceedingly well thus far and is a great improvement over the old arrangement where each division was practically independent. Under such a system it was impossible to secure uniform teaching.
>
> We have stated conferences each quarter, at which all college, station and extension workers are present. All questions of college policy are threshed out at these conferences and there are also frequent discussions relative to what constitutes sound advice to the farmers of the state. The organization being departmental there is every opportunity for the college, station and extension workers within a department to keep in thorough touch with each other.

There is evidently much to be said in support of each type of organization and it may be added that the testimony from each of the forty-eight states is that the type of organization prevailing in that state is working well. As nearly as the writer can judge the following states, twenty-seven in number, carry on the extension work largely independent of the teaching and research heads except for an advisory capacity and the supervision of subject matter: Arkansas, Delaware, Florida, Georgia, Idaho, Kansas, Louisiana, Maine, Maryland, Minnesota, Mississippi, Nebraska, Nevada, New Hampshire, New Jersey, North Dakota, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Tennessee, Texas, Utah, Vermont, Washington and Wyoming.

Those in which the extension work, save for administrative matters, is handled largely within the several departments so that each department is the unit for teaching research and extension are twenty-one in number, as follows: Alabama, Arizona, California, Connecticut, Colorado, Illinois, Indiana, Iowa, Kentucky, Missouri, Montana, Michigan, Massachusetts, New York, New Mexico, North Carolina, Ohio, South Carolina, Virginia, West Virginia and Wisconsin.

METHODS EMPLOYED IN INFORMING EXTENSION WORKERS OF RESULTS OF EXPERIMENTAL WORK IN PROGRESS AT THE EXPERIMENT STATIONS

One of the dangers of extension work is that on account of the large demands for service in the field, meetings, conferences, demonstration work and the like, the extension worker finds but little time for reading and for keeping up to date concerning the results of the most recent investigations in his line of work. The extension worker cannot afford either for his own sake or for that of the people he serves to neglect keeping himself abreast of the times. Most extension directors specifically suggest that the specialists spend at least one day per week at headquarters for the purpose of conferences, office work and the keeping in touch with the latest developments in their respective lines of work either at their own experiment station or through the bulletins issued by other stations.

Some of the suggestions that have been made as to how the extension workers could best keep well informed are as follows:

Weekly departmental conference, at which time all members of the department, including station workers, college workers and extension men are are called in. At this time each division reports any progress of work in the department and the extension man reports any progress that is made in his work throughout the State.

The presentation of the experimental work in detail by the director of the experiment station before the extension staff yearly, or oftener.

The location of the extension men with the department in which they do their work.

The publication of a weekly agricultural news letter.

One institution expects the extension workers to remain at the college one week out of three. This gives them an opportunity to get in touch with the experimental work in progress and to keep in close association with those who are engaged in teaching and in experimental work.

In certain institutions the entire extension force visits the different departments every two or three months. The head of the department presents the projects and tells of the progress being made in the various experiments under headway.

Special meetings are held at times when the experiments can best be inspected and lessons drawn from the work in progress. In Ohio a wheat day was held, when the matters of crop rotation, varieties and fertilization were discussed. The crops were in such a stage of maturity that lessons could best be drawn.

In some states a monthly news letter is sent out to the county agents and the extension representative. These write-ups give account of the experimental work in progress and afford opportunity for the resident instructional and experimental staff to place before farmers the latest results and lessons from experimental investigations.

KEEPING COLLEGE AND EXPERIMENT STATION WORKERS INFORMED AS TO THE PROBLEMS AND CONDITIONS IN THE STATE

College teachers and those engaged in research are just as likely to grow stale in certain directions as the extension worker. The local character of teaching and experimental work with the consequent lack of opportunity to get into first hand touch with the people of the state and their problems makes the teacher and the investigator constantly dependent on the extension worker for knowledge of the actual situation in the field and of the most pressing problems that call for investigation.

Many of the directors of experiment stations and extension service as well as heads of departments feel that where the department is the unit for the three lines of work and the extension workers are located with the department the organization itself naturally takes care of this problem since the teaching staff, the research men and the extension workers are intimately associated.

Some of the suggestions for keeping those engaged in resident work informed as to the situation in the field are the following:

At the beginning of the year the specialist prepares a plan for the year's work, which after approval by the head of the department, is placed in the hands of the dean of the college of agriculture. Quarterly reports are made of the work being done by the extension specialists, from which the college can judge of the progress made by the extension agents in carrying out the plan of work for the year.

An attempt is made in some institutions to keep the resident workers in touch with extension matters by inviting the subject matter heads to take part in extension conferences, when programs of work are being formulated.

Members of the teaching and station staff are frequently informed regarding the problems in the state, through occasional farm visits and definite assignments to extension work, such as judging, demonstration and lecture work.

In some States the extension service holds a public conference every Monday morning, which is open to all those who care to attend. In other States these conferences are held once a month and the experiment station likewise holds a monthly conference to which the extension representatives are invited.

Copies of annual extension reports as well as various other reports are filed in one state with the chairman of the dairy department. In the future it is planned to file carbon copies for each trip report with him, so that the department may be kept posted with all information on field activities up to date. In other states a summary of the county agents and extension specialists weekly or monthly reports are prepared and sent to the college and station workers.

A unique publication is issued at one institution which contains statements dealing with teaching, research and extension. It represents the interests of the whole institution rather than of the extension department solely. The members of the staff are thus kept informed as to the progress in the different departments.

DIFFICULTIES

The problems are not all solved by any means. Many difficulties present themselves both to the college and experiment station workers as well as to the extension workers. The most common obstacles in the way of resident work appear to be a lack of money and equipment for teaching and research. The extension man usually runs up against problems which need an immediate solution. Usually these problems cannot be solved by the experiment station immediately on account of the fact that other experiments may already be under headway. College dairy herds are not large enough to use on the very extensive experiments and this condition cannot be remedied except with an enlargement of the dairy activities of the college and the experiment station.

Some of the extension workers feel that the experiment station staff is devoting too much attention to problems that have long ago been solved either by the people of the state or by other experiment stations. In other words, they are running experiments that are not of present interest to the people. They feel that marketing, farm management and agricultural economics have not received their just portion of the experiment station's attention and that these are really the important present day problems on which they need the most help.

One criticism of teaching and research work has been that the commercial application is limited. In many cases the industry cares little for basic findings which bear in a general way on the industry. Scientific results are preferred which can be immediately applied and which will increase the returns and lessen the efforts of the dairy farmers of the state.

Another of the difficulties from the extension standpoint is in obtaining definite and usable information from the subject matter departments in such form that it may be used for extension meetings.

Extension work in most states has had more funds available than has research or college work. The result has been that extension work has out-run the other lines of activity and is calling for the solution of problems which the experiment station with its present facilities is not in position to undertake.

The successful teacher and research man is frequently drawn upon for so many talks and reports concerning his investigations that he finds his research work very much handicapped from the point of being able to devote a proper amount of time to it. There has been a feeling at times that the extension work gives a better opportunity for acquaintanceship throughout the state, and for this reason college men are prone to neglect their resident work for some form or other of extension activity.

Regular class work interferes with extension work and if the men are taken out of classes to do extension work this seriously handicaps the instruction.

Men who give all of their time to instructional work some times feel that they are not making the progress for themselves that the station and extension workers are.

The director of one experiment station makes the following comment:

> All progressive members of our extension staff recognize that station research has not been keeping pace with the development of agricultural extension. The remedy lies in the employment of better trained research workers, a greater degree of coöperation in research at our institutions and more adequate financial support of station research.
>
> The difficulties that the college and station workers experience in their dealing with extension problems are concerned chiefly with the failure of the average extension worker to keep himself posted on the progress of agricultural research in this country and abroad. The average extension worker does not read and study sufficiently to be of the greatest value to his institution and to his constituency. Moreover, any college or station worker who shows progress in his chosen field is promptly appropriated by the extension service and ultimately is compelled to neglect his research, and at times even his teaching, to meet the needs of the extension service.

One extension specialist in dairying makes the following suggestion:

> My own personal opinion is, after four years' experience, that the future extension man must be first of all an investigator. He appreciates the problems in a much different way than does the man who is solely investigator. Then he must have the additional qualification of being able to present clearly to good audiences the results of his and of other investigations. Instead of so much lecturing, as he is now doing, he will go into the field and find out what the problems are and solve them if possible, because primarily the farmer is most interested in the solution of his problems.

The director of extension in another state comments as follows:

> Some of the chief obstacles and difficulties from the extension point of view concerning the college and station work are, first, that the general agricultural public is not always interested and for that reason do not always support the work being done at the College and Experiment Station. This lack of support, I believe, is largely due to the fact that the general public or even the readers in agricultural affairs have no part in planning and determining of problems for investigation and research. I believe the way to overcome this difficulty is to secure the coöperation of all parties concerned before a problem of research is undertaken. The parties concerned here consist of the experiment station staff, the farmers, and the extension workers. These people should get together or their representatives, and discuss freely and carefully the problems that are most in need of solution and the ones that the farmers are most anxious to have solved. This will bring, I believe the interest and support of the farmers. The extension workers can assist the experiment station men in maintaining the proper contact with the field during the process of investigation. The research man will be more likely to keep his work more nearly in line with the immediate needs of agriculture and through the extension service can make the proper contacts with the farmers.
>
> Something of the same difficulty obtains on the part of the research man with regard to the extension work as obtains on the part of the farmer with respect to research work. The investigator must know more about the farmers' point of view and be able to make better contacts with the field conditions in order for him to become thoroughly cognizant of the position and point of view of the extension workers.

The general consensus of opinion is that the chief difficulties between extension activities and college and station work result from the lack of a proper understanding and appreciation of the functions of the experiment station, the college of agriculture and the extension service. It is suggested that the teaching force, the investigators and the extension workers in a particular field of activity, such as dairying, have their offices in the same building, and that all workers be called together at frequent intervals to discuss problems in each line of work so as to promote common interest and mutual understanding.

Difficulties and misunderstandings may largely be eliminated by the employment of a satisfactory personnel in the three lines of work, and by establishing and maintaining close personal contacts between the different classes of workers. Personnel is of especial importance. The best of plans will fail in the hands of an inferior personnel, whereas an ordinary plan will be improved and made to work satisfactorily in the hands of the right kind of men. One of the principal qualifications of a satisfactory personnel is a sincere spirit and an honest desire to give good service and the absence of petty selfishness and over-sensitiveness about credit. There should be a mutuality of interests among college, station and extension men, each recognizing the function of the other and the impossibility of the exercise of any of these functions without common sense and wholesome relationship among the groups. We all need to be imbued with the spirit of unselfish public service.

We need to recognize that teaching, investigation and extension are component parts of one great organization for the improvement of agriculture and that the best way for each of us to get the most good from the organization is to do all in his power to make that organization a success.

A STUDY OF THE FACTORS THAT INFLUENCE THE COAGULATION OF MILK IN THE ALCOHOL TEST[1]

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The alcohol test is being used to some extent as a test for grading milk. The test is usually made by adding 2 cc. of milk to 2 cc. of alcohol in a test tube. The test tube is then closed with the thumb, inverted several times and examined. If no precipitate is formed the test is said to be negative, and if a precipitate is formed the test is said to be positive. The strength of the alcohol used is usually 68 or 70 per cent by volume.

When the test first came into use in 1890 it was regarded largely as a measure of acidity. However it was soon found that fresh milk from individual cows frequently coagulates and that the test was dependent upon other factors as well as upon acidity. Nevertheless the test was still used for it was thought that besides acidity it detected other undesirable characteristics. Thus Ernst (1) believed that a positive test of fresh milk was due to irritation of the milk glands. Ruhm (2), Rullman and Trommsdorf (3), and Campbell (4) claimed that a positive test was due to infected or diseased udders. Metzger (5) found that infection of the uterus and animals lean from disease caused a positive test. Auzinger (6) stated that milk from cows with infected vaginas and cows that had aborted was positive to the test. Henkel (7), Metzger (5) and Auzinger (6) found that colostrum milk influenced the test.

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[1] Published with permission of the Director of Wisconsin Agricultural Experiment Station.

[2] The work presented in this paper constitutes the thesis of T. H. Binney, submitted in partial fulfillment of the requirements for the degree of Master of Science in the graduate school of the University of Wisconsin, 1922.

These various causes listed in the literature are only remote causes, they are operative only in so far as they affect the chemical composition and properties of the milk. As far as we are aware the only other direct causes mentioned besides acidity are the effect of rennet forming organisms studied by Ayers and Johnson (8), and the effect of the milk salts, especially calcium, observed by Auzinger (6).

Thus it is apparent that our knowledge of the direct causes for the alcohol coagulation is incomplete. It is the purpose of the work reported in this paper to determine the factors influencing the alcohol test and to study their relative importance.

METHOD USED

In this work both 70 and 75 per cent alcohol by volume were used. The alcohol used was distilled in the presence of sodium hydroxide to remove any acid which might be present. This distilled alcohol was then adjusted to the desired strength by the addition of distilled water. The strength was determined by means of the Westphal balance. The 70 per cent alcohol by volume was adjusted to a specific gravity of 0.8900 at 15°C. and the 75 per cent alcohol by volume to a specific gravity of 0.8773.

In each case, except where otherwise indicated throughout this work, 2 cc. of milk were added to 2 cc. of alcohol in a test tube. The test tube was then closed with the thumb, inverted several times and examined for the appearance of the precipitate. The mixtures were then very carefully examined and on the appearance of the slightest precipitate the tests were called positive. Any additional methods used in this work will be explained when the experiments in which they were used are discussed.

THE EFFECT OF MILK SALTS

It is a well known fact that electrolytes have a very marked effect on the stability of colloids, especially electrolytes that yield doubly and triply charged ions on dissociation. In the case of milk we are dealing with a colloidal solution of albumin and casein in the presence of the milk salts containing the bivalent calcium and magnesium and the trivalent phosphate and citrate radicles. We would expect, then, that the stability of the milk proteins would be influenced by the amounts of these salts present. Van Slyke and Hart (9) and Van Slyke and Bosworth (10) actually found in working with calcium compounds of casein that the presence of small amounts of soluble calcium salts have a very marked effect upon the solubility of the casein compounds.

More recently it has been shown by Sommer and Hart (11) that the calcium and magnesium and the citrates and phosphates present in the milk have a very marked effect upon the heat coagulation of milk, as in the sterilization of evaporated milk. It was shown that there is a balancing effect between calcium and magnesium on the one hand, and the citrates and the phosphates on the other, the proper balance of these producing the most stable condition, an excess of either of these causing the milk to coagulate more readily on heating.

That the milk salts are also of importance in the alcohol test was indicated by the work of Auzinger (6). Working with the milk from three cows he was able to change the alcohol test from negative to positive by feeding each cow 120 grams of calcium phosphate per day. However, other investigators have continued to give other reasons for the test and as a result have either contradicted or obscured Auzinger's conclusions.

In order to determine experimentally what effect the various milk salts have on the alcohol test they were added to milk in varying amounts and the alcohol test applied. Fourth-molar solutions of calcium acetate, magnesium chloride, potassium chloride, di-potassium phosphate and sodium citrate were prepared and added to 25 cc. of fresh milk in a series, increasing the amounts of the salt solution by 0.1 cc. In each series the dilution was equalized by the addition of the proper amount of distilled water. The results are given in table 1. Table 1 shows that 0.2 cc. of M/4 calcium acetate and 0.1 cc. of M/4 magnesium chloride added to 25 cc. of fresh milk was sufficient to cause a positive reaction with the alcohol test. These additions are equivalent to an increase of 0.0112 and 0.0040 per cent CaO and MgO, respectively. As high as 0.9 cc. of M/4 potassium chloride, di-potassium phosphate, and sodium citrate were added to 25 cc. of milk and the milk still gave a negative test with alcohol.

The results show that a slight increase in the calcium or magnesium content of the milk will cause a positive reaction with the alcohol test, while an increase of potassium, sodium chloride, citrate and phosphate will not cause a positive test.

TABLE 1

Effect of salts on alcohol test

25 CC MILK PLUS												STRENGTH OF ALCOHOL PER CENT BY VOLUME
	WATER, CC	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0	
	SOLUTION, CC	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	
M/4 calcium acetate		−*	−	+	+	+	+	+	+	+	+	75
		−	−	−	+	+	+	+	+	+	+	70
M/4 magnesium chloride		−	+	+	+	+	+	+	+	+	+	75
		−	−	+	+	+	+	+	+	+	+	70
M/4 potassium chloride		−	−	−	−	−	−	−	−	−	−	75
		−	−	−	−	−	−	−	−	−	−	70
M/4 di-potassium phosphate		−	−	−	−	−	−	−	−	−	−	75
		−	−	−	−	−	−	−	−	−	−	70
M/4 sodium citrate		−	−	−	−	−	−	−	−	−	−	75
		−	−	−	−	−	−	−	−	−	−	70

* Plus and minus signs indicate positive and negative alcohol tests respectively, under the conditions indicated in the table.

SALT BALANCE

In order to determine whether the effects of the milk salts on the alcohol test counteract each other in a manner similar to the salt balance demonstrated in the heat coagulation, the effect of various combinations of salts was studied.

Table 2 shows the results of the alcohol test on three different combinations of salts in varying proportions. Using the same fresh milk throughout the experiment three series of samples were prepared. Each series consisted of ten portions of 25 cubic centimeters each. To each of the samples in all three series 0.5 cc. of M/4 calcium acetate was added. This was sufficient to make the alcohol test distinctly positive. To these three series M/4 di-potassium phosphate, potassium chloride, and sodium citrate, respectively, were added in amounts ranging from 0.1 to 1.0 cc. On applying the alcohol test it was found that the coagulation caused by the 0.5 cc. of M/4 calcium acetate was prevented by 0.5 cc. of M/4 sodium citrate and by 0.6 cc.

TABLE 2

The effect of salts on the alcohol test

25 CC MILK PLUS											STRENGTH OF ALCOHOL PER CENT BY VOLUME
M/4 ACETATE, CC.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
M/4 SOLUTION, CC.	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	
M/4 potassium phosphate	+*	+	+	+	+	–	–	–	–	–	75
	+	+	+	+	–	–	–	–	–	–	70
M/4 potassium chloride	+	+	+	+	+	+	+	+	+	+	75
	+	+	+	+	+	+	+	+	+	+	70
M/4 sodium citrate	+	+	+	+	–	–	–	–	–	–	75
	+	+	+	–	–	–	–	–	–	–	70

* See table 1.

TABLE 3

The effect of salts on the alcohol test

25 CC. MILK PLUS											STRENGTH OF ALCOHOL PER CENT BY VOLUME
M/4 Mg CHLORIDE, CC	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.5	
M/4 SOLUTION, CC	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	
M/4 potassium chloride	+*	+	+	+	+	+	+	+	+	+	75
	+	+	+	+	+	+	+	+	+	+	70
M/4 potassium phosphate	+	+	+	+	+	+	+	–	–	–	75
	+	+	+	+	+	+	–	–	–	–	70
M/4 sodium citrate	+	+	+	+	–	–	–	–	–	–	75
	+	+	+	–	–	–	–	–	–	–	70

* See table.

of di-potassium phosphate. The potassium chloride did not counteract the effect of the calcium salt.

Table 3 shows the results of the alcohol test on three series similar to those in table 2. Instead of using calcium acetate to cause the milk to become distinctly positive, M/4 magnesium chloride was used in table 3. It was found that the coagulation caused by the 0.5 cc. of M/4 magnesium chloride was prevented by 0.8 cc. of M/4 di-potassium phosphate, and 0.5 cc. of M/4 sodium citrate, respectively. The potassium chloride did not prevent the coagulation caused by the magnesium chloride.

These experiments demonstrate that the salt composition of the milk has a marked effect upon the alcohol coagulation. Small increases in the amount of CaO (0.0112 per cent) and MgO (0.0040 per cent) cause a positive alcohol test. The effect of the calcium and magnesium is counteracted by the citrates and phosphates in the milk, so that a positive test with fresh milk depends upon the relative amounts of these four salts present in it.

The importance of the salt composition of the milk as a factor influencing the alcohol coagulation becomes more apparent when we compare the amounts of the salts that will produce an effect on the coagulation with the amounts of these salts normally present in milk. In the above experiments it was demonstrated that an increase of 0.0112 per cent in the CaO content changed a negative sample to a positive one. Compare this with the normal differences that are found between samples of milk, Sommer and Hart (11) in an analysis of 30 different samples found the CaO content to vary from 0.132 to 0.210 per cent.

FEEDING EXPERIMENT

The effect of the salts on the alcohol coagulation has thus far been demonstrated entirely by their addition to various samples of milk. The additions of salts which were found effective were very small, well within the limits of normal variation of these compounds in milk. In spite of these facts there might be doubt in the minds of some people because these salts were added and were not secreted by the cow as a part of the milk. In order to overcome this objection a feeding experiment was conducted to determine what effect the feeding of calcium would have on the alcohol test.

Three heavy producing cows in the middle of the lactation period were selected for the experiment. The time of the experiment was divided into four periods. The first or pre-period was an observation period to determine how far from the coagulating point the milk of the animals was, and to note fluctuations and irregularities in the test. During the second period which was from the eighth to the fourteenth day, 50 grams of calcium carbonate was fed to each animal per day. The third period, from the fourteenth to the twenty-second day, the animals were fed 100 grams of calcium carbonate per day. During the fourth period, from the twenty-second to the twenty-eighth day, each animal was fed 200 grams of calcium carbonate per day. The fifth period immediately followed the feeding of the last of the calcium carbonate, up to the time the milk reached the same condition as in the pre-period. The basal ration during the entire experiment consisted of 14 to 16 pounds of grain mixture (500 pounds corn; 200 pounds oats; 200 pounds bran; 100 pounds oil meal); 10 pounds of alfalfa hay and 30 pounds of corn silage. On the evening of the twenty-fourth day the cows refused to eat all of the calcium carbonate. The next day only 100 grams were fed. On the twenty-sixth day 200 grams were again fed and the feeding continued without any changes in amounts.

On the basis of the preceding demonstration that the milk salts are an important factor in the alcohol coagulation, an attempt was made to measure the extent to which a sample was positive or negative. If a sample was negative 5 cc. of milk was taken and M/20 calcium acetate was added in amounts just sufficient to cause a positive test. This amount is indicated in column 3 of table 4. Similarly, if the sample was positive 5 cc. of milk was taken and M/20 potassium phosphate was added in amounts just sufficient to cause a negative test. This amount is recorded in column 4 of table 4. The results are more strikingly pictured in graphs 1, 2 and 3.

TABLE 4

Effect of feeding calcium carbonate on the alcohol test

DATE	COW								
	Alice			Bud			Doll		
	Alcohol test	M/20 Ca acetate per 5 cc milk	M/20 K phosphate per 5 cc milk	Alcohol test	M/20 Ca acetate per 5 cc milk	M/20 K phosphate per 5 cc milk	Alcohol test	M/20 Ca acetate per 5 cc milk	M/20 K phosphate per 5 cc milk
Pre-period									
		cc	cc		cc	cc		cc	cc.
February 15	–	0.2		–	0.2		–	0.2	
February 16	–	0.2		–	0.2		–	0.3	
February 17	–	0.2		–	0.3		–	0.3	
February 18	–	0.2		–	0.3		–	0.1	
February 20	–	0.2		–	0.3		–	0.2	
February 21	–	0.2		–	0.3		–	0.2	
February 23	–	0.2		–	0.25		–	0.2	
February 23	–	0.2		–	0.3		–	0.2	
February 24	–	0.2		–	0.2		–	0.2	
February 24	–	0.2		–	0.4		–	0.2	
50 grams Ca carbonate per day									
February 25	–	0.2		–	0.3		–	0.2	
February 25	–	0.2		–	0.25		–	0.2	
February 26	–	0.2		–	0.2		–	0.2	
February 26	–	0.1		–	0.2		–	0.2	
February 27	+		0.1	–	0.1		–	0.1	
February 27	+		0.15	–	0.05		–	0.05	
February 28	–	0.025		–	0.05		–	0.05	
February 28	+		0.15	–	0.05		–	0.05	
March 1	+		0.15	+		0.1	–	0.05	
March 2	+		0.1	+		0.1	+		0.1
March 2	+		0.1	+		0.1	+		0.1
100 grams Ca carbonate per day									
March 3	+	–	0.1	+		0.1	+		0.1
March 3	+	–	0.1	+		0.1	+		0.1
March 4	+	–	0.1	+		0.1	+		0.1
March 5	+	–	0.3	+		0.25	+		0.2
March 6	+	–	0.3	+		0.2	+		0.3
March 7	+	–	0.4	+		0.3	+		0.4
March 8	+	–	0.3	+		0.3	+		0.3
March 9	+	–	0.4	+		0.3	+		0.5
March 10	+	–	0.4	+		0.2	+		0.5

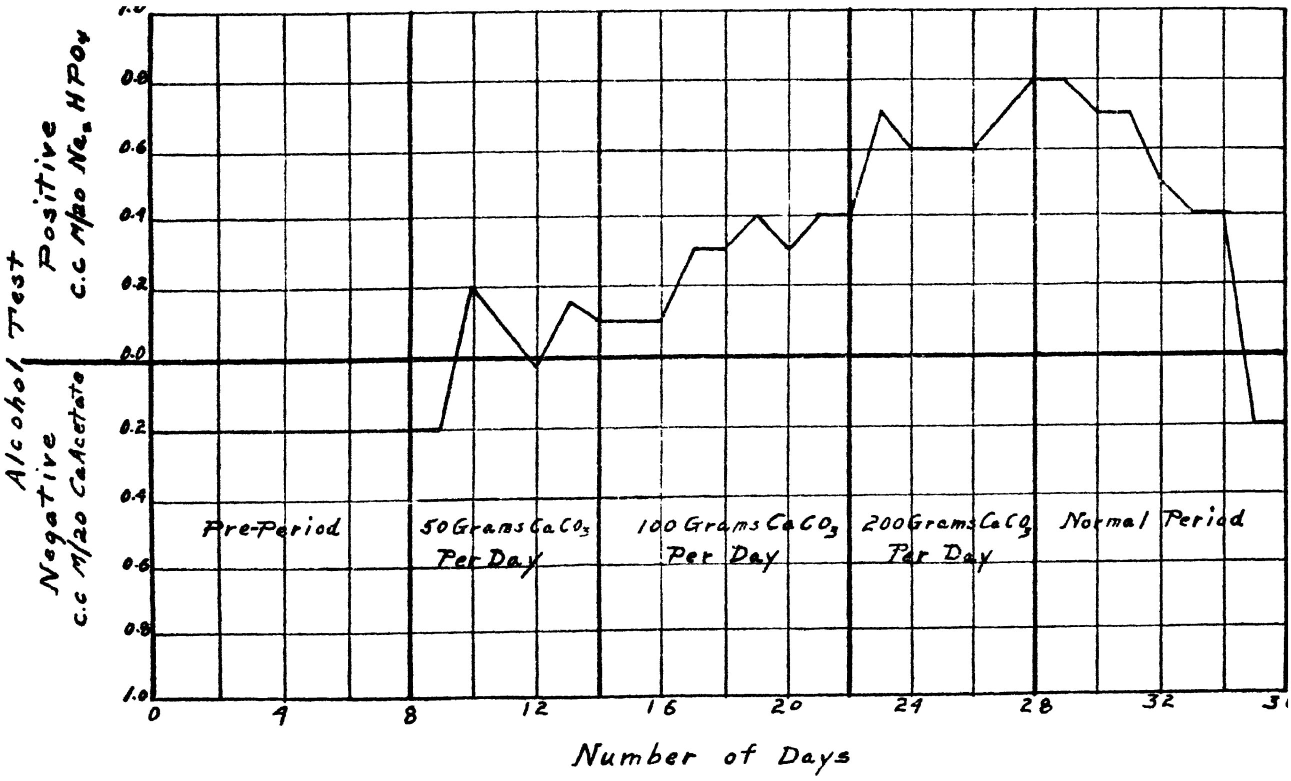
TABLE 4—*Continued*

DATE	COW								
	Alice			Bud			Doll		
	Alcohol test	M/20 Ca acetate per 5 cc milk	M/20 K phosphate per 5 cc milk	Alcohol test	M/20 Ca acetate per 5 cc milk	M/20 K phosphate per 5 cc milk	Alcohol test	M/20 Ca acetate per 5 cc. milk	M/20 K phosphate per 5 cc milk
200 grams Ca carbonate per day									
		cc.	cc		cc.	cc.		cc.	cc.
March 11	+		0.7	+		0.6	+		1.3
March 12	+		0.6	+		0.6	+		0.8
March 13	+		0.6	+		0.6	+		0.7
March 14	+		0.6	+		1.0	+		0.7
March 15	+		0.7	+		?	+		0.8
March 16	+		0.8	+		0.7	+		0.8
Normal period									
March 17	+		0.8	+		0.8	+		0.7
March 18	+		0.7	+		0.8	+		0.7
March 19	+		0.7	+		0.8	+		0.7
March 20	+		0.5	+		?	+		0.6
March 21	+		0.4	+		0.6	+		0.5
March 22	+		0.4	+		0.3	+		0.1
March 23	−	0.2		−	0.3		−	0.1	
March 24	−	0.2		−	0.2		−	0.1	

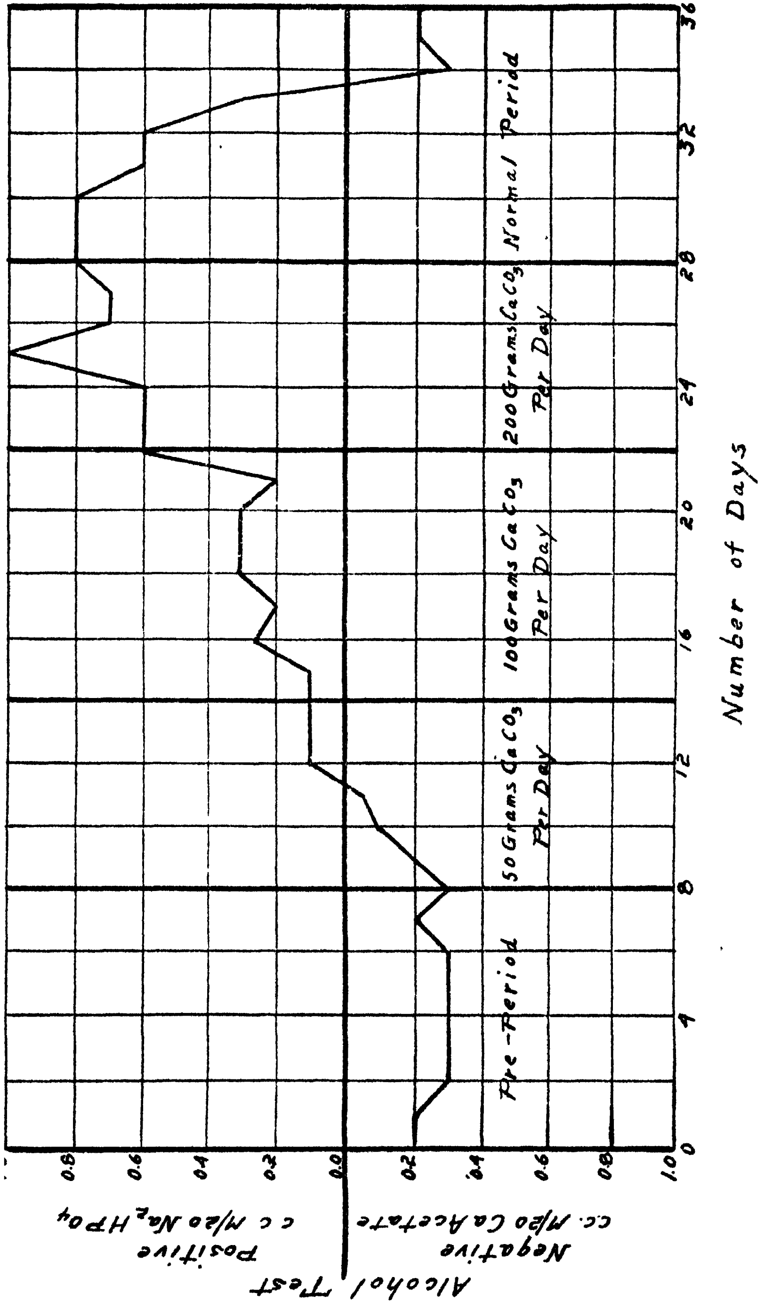
It is not to be inferred that the change in the composition of the milk can be calculated directly from the amount of M/20 calcium acetate and M/20 di-potassium phosphate added in the above manner. This procedure was used merely as a convenient measure of the degree to which the alcohol test was either negative or positive. That there actually was no appreciable increase in the total amount of calcium oxide in the milk as the result of feeding the calcium carbonate is shown in table 5.

RELATIVE IMPORTANCE OF THE EFFECT OF ACIDITY AND OF THE MILK SALTS

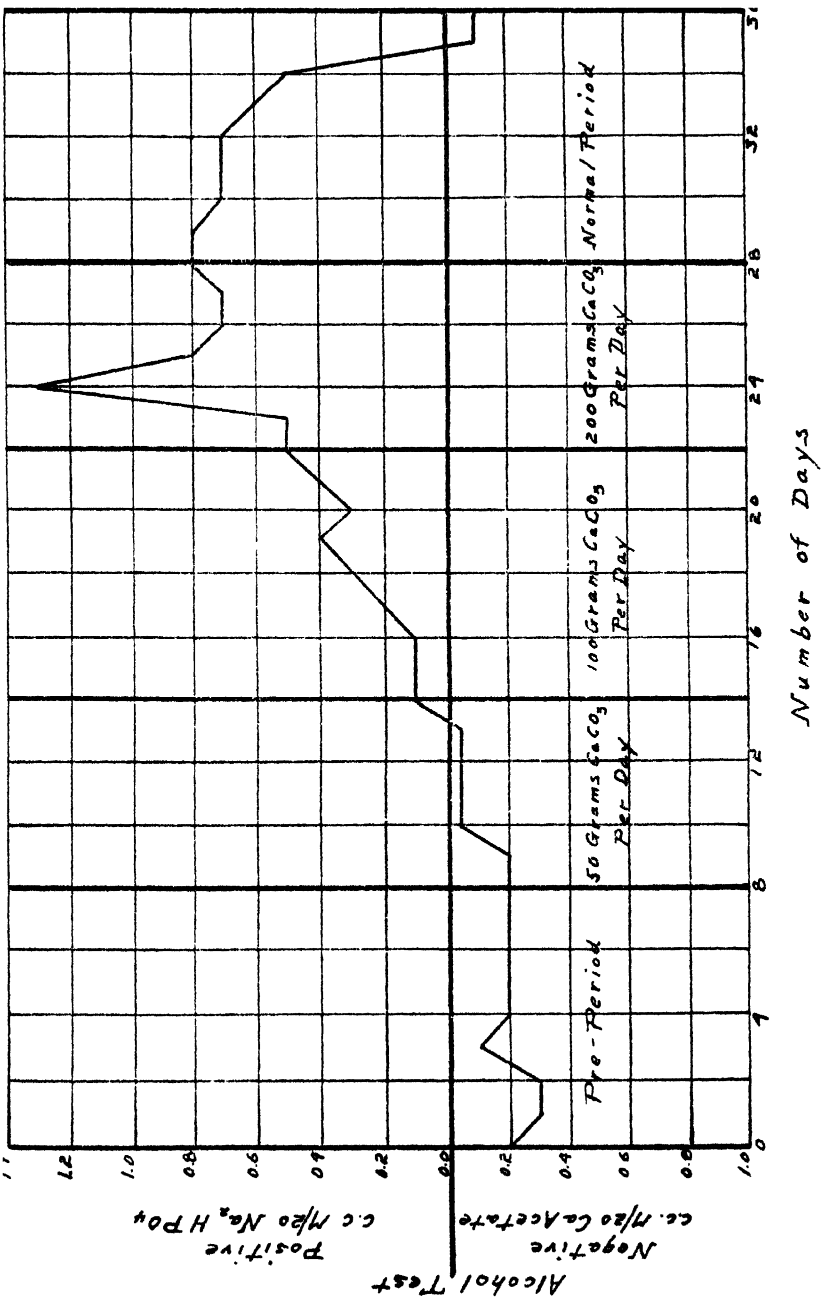
The relation of the acidity to the alcohol test has received much consideration, and the assumption at first was that the



GRAPH 1. THE EFFECT OF $CaCO_3$ IN THE RATION ON THE ALCOHOL TEST OF THE MILK. COW—ALICE



GRAPH 2. THE EFFECT OF $CaCO_3$ IN THE RATION ON THE ALCOHOL TEST OF THE MILK. COW—BUD



Graph 3. The Effect of $CaCO_3$ in the Ration on the Alcohol Test of the Milk. Cow—Doll

alcohol test was a good measure of the acidity. However it has been shown by a number of investigators that there is no strict parallelism between the alcohol text and the acidity.

Dahlberg and Garner (12) found that the results of a study of 211 samples of milk "showed conclusively that there is no direct relation between coagulation of milk with 75 per cent alcohol and the acid content of the milk as measured by titration."

This lack of agreement between the alcohol test, acidity, and also the bacterial counts, is most strikingly demonstrated in the results of Ayers and Johnson (8). Thirty-five samples of raw market milk ranging in acidity from 0.14 to 0.32 per cent and in bacterial count from 2100 to 21,200,000 per cubic centimeter were alcohol positive to 75 per cent alcohol while 142 samples with acidity ranging from 0.09 to 0.19 per cent and bacterial counts from 2000 to 19,600,000 were alcohol negative. From their results they "believe that there is no definite relation between the alcohol test and the bacterial count, except in special cases where the bacteria have developed to a point where there is sufficient acid produced or where rennet-forming bacteria have acted sufficiently to influence the test." Ayers and Johnson (8) attempted to account for these wide discrepancies by pointing out (*a*) that in the early stages of bacterial growth the development of acid and rennin-like enzymes is very slow in proportion to the bacterial growth, (*b*) that there may be inert bacteria present that may contribute to the bacterial count without contributing to the acidity, (*c*) that there may be other bacteria present that develop but do not affect the alcohol

TABLE 5

The effect of feeding $CaCO_3$ on the CaO content of the milk

PERIOD	ALICE	BUD	DOLL
	per cent CaO	*per cent CaO*	*per cent CaO*
Pre-period	0.187	0.170	0.153
50 grams $CaCO_3$ per day	0.184	0.170	0.157
100 grams $CaCO_3$ per day	0.187	0.174	0.158
200 grams $CaCO_3$ per day	0.186	0.175	0.155
Control period	0.185	0.171	0.154

coagulation. This explanation seems inadequate to account for the wide discrepancy which they observed, the bacterial count in 142 alcohol negative samples ranging from 2000 to 19,000,000 per cubic centimeter. Moreover, this explanation cannot possibly account for their results in which out of 35 samples of raw milk that were alcohol positive, 10 samples had bacterial counts ranging from 2100 to 67,000 per cubic centimeter. In these cases, in the light of their explanation, there certainly could not have been sufficient change produced by the bacteria to cause a positive alcohol test, nevertheless, the tests actually were positive.

These discrepancies can easily be accounted for if we take into consideration the effect of the milk salts. In order to determine experimentally the relative importance of the effect of the milk salts and the effect of acidity the following experiment was conducted:

A sample of milk was divided into two lots. One lot was kept sweet; to the other lot a small amount of starter was added and it was allowed to develop an acidity of 0.42 per cent. By mixing these two lots of milk in proper proportions three series of milk samples were prepared, each series ranging in acidity from 0.12 to 0.38 per cent. Twenty cubic centimeters of the milk was placed in each beaker of three series. The first series was allowed to remain normal; 0.1 cc. M/4 calcium acetate (equivalent to 0.007 per cent CaO) was added to the second, and 0.1 cc. M/4 potassium phosphate (equivalent to 0.0088 per cent P_2O_5) was added to the third. The milk was then tested with the alcohol test and the results tabulated.

As shown in table 6 normal milk became positive to the alcohol test when the acidity had reached 0.26 per cent. The milk to which calcium acetate had been added became positive at 0.20 per cent acidity; and the milk to which potassium phosphate had been added did not become positive until the acidity had reached 0.30 per cent.

The results of this experiment show:

1. That acidity affects the alcohol test.
2. That the effect of the acidity and the salts are additive.

3. That 0.0070 per cent CaO is equivalent to an increase in acidity of 0.06 per cent.

4. That 0.0088 per cent P_2O_5 is equivalent to a decrease in acidity of 0.04 per cent.

From this we can conclude that the effect of the milk salts is of such importance that it can easily account for any lack of correlation between the alcohol test, acidity, and bacterial counts.

TABLE 6

Relative effect of the acidity and of the milk salts on the alcohol test

20 cc NORMAL MILK			20 cc MILK PLUS 0.1 cc. M/4 Ca ACETATE			20 cc MILK PLUS 0.1 cc M/4 K PHOSPHATE		
Acidity	Alcohol test		Acidity	Alcohol test		Acidity	Alcohol test	
	75 per cent	70 per cent		75 per cent	70 per cent		75 per cent	70 per cent
0.12	−*	−	0.12	−	−	0.12	−	−
0.14	−	−	0.14	−	−	0.14	−	−
0.16	−	−	0.16	−	−	0.16	−	−
0.18	−	−	0.18	−	−	0.18	−	−
0.20	−	−	0.20	+	−	0.20	−	−
0.22	−	−	0.22	+	+	0.22	−	−
0.24	−	−	0.24	+	+	0.24	−	−
0.26	+	−	0.26	+	+	0.26	−	−
0.28	+	+	0.28	+	+	0.28	−	−
0.30	+	+	0.30	+	+	0.30	+	−
0.32	+	+	0.32	+	+	0.32	+	+
0.34	+	+	0.34	+	+	0.34	+	+
0.36	+	+	0.36	+	+	0.36	+	+
0.38	+	+	0.38	+	+	0.38	+	+

* See table 1.

INFLUENCE OF THE ACTION OF RENNET

The action of rennet has been studied as one of the factors which influence the alcohol test. Ayers and Johnson (8) tried the effect of prepared rennet and rennet of bacterial origin on the test.

In this work two experiments were also conducted. First, the action of prepared rennet was tried. Rennet was added to six flasks of fresh milk to form dilutions ranging from 1 part of rennet to 25,000 parts of milk, up to 1 part of rennet to 150,000 parts of milk. For the first fifteen minutes the milk in each flask was tested by the alcohol test at intervals of five minutes. At the end of that period the milk was tested at intervals of fifteen minutes until the milk in each flask became positive.

An examination of table 7 shows that the flask of milk of the lowest dilution was first to show a positive test, the time being thirty minutes. The flask of milk of highest dilution became positive in one hundred and eighty minutes.

It is evident that rennet will produce changes in milk which will cause a positive test. The amount of rennet and the time it is allowed to act are determining factors. The acidity of the milk did not increase sufficiently to affect the test in the short time the experiment was run and therefore can be disregarded.

TABLE 7

Influence of prepared rennet on alcohol test

TIME IN MINUTES	0		5		10		15		30		45		60		90		120		180	
Alcohol (per cent by volume)	75	70	75	70	75	70	75	70	75	70	75	70	75	70	75	70	75	70	75	70
Dilution:																				
1:150.000	*−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+
1:125,000	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	+
1:100,000	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	+	+	+
1:75,000	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	+	+	+	+	+
1:50,000	−	−	−	−	−	−	−	−	−	−	+	+	+	+	+	+	+	+	+	+
1:25,000	−	−	−	−	−	−	−	−	+	+	+	+	+	+	+	+	+	+	+	+

* See table 1.

In order to determine the importance of the rennet forming organisms as a factor influencing the alcohol test, an experiment was conducted in which sterilized milk was inoculated with a culture of a rennet forming organism.

Ayers and Johnson (8) had carried on several similar experiments in which they inoculated sterilized milk with a rennet forming organism and determined the bacterial count at the time the alcohol test became positive. They found that as high a count as 9,000,000 and 15,000,000, per cubic centimeter was required before the milk became positive. As a measure of the relative importance of rennet forming organisms as a cause for the alcohol test, their experiment is open to criticism; it does not take into consideration the fact that heating the milk removes it farther from the coagulating point.

Auzinger (6) found that milk which gave a positive test at 15°C. sometimes did not give the test after it had been heated for thirty minutes at 60°C. Ayers and Johnson also investigated the effect of heat on the alcohol test and found that milk which had been positive frequently was negative after it had been heated.

No explanation has been offered for this change from positive to negative as the result of heating. This change can now readily be explained on the basis of the effect of the milk salts.

It has been demonstrated by numerous investigators, Soldner (13) Boekhout and De Vries (14), Purvis, Brehaut and McHattie (15), and Grosser (16), that when milk is boiled a precipitation of a portion of the calcium phosphates occurs, the amount of precipitation being proportional in general to the degree and duration of heat applied.

Since small amounts of calcium will cause a positive test, a reduction in the soluble calcium as a result of the heating can readily account for the change from positive to negative. A reduction in the soluble calcium will not only change a positive sample to a negative but will make a negative sample even more negative. Therefore, conclusions drawn on the basis of work with sterilized milk are misleading.

In order to overcome this objection to the use of sterilized milk, an attempt was made to adjust the sterilized milk in such a manner that it was negative to the same degree as the unsterilized milk.

A sample of fresh milk was divided into 200 cc. lots and placed in flasks. Twentieth-molar calcium acetate was added to one flask until it just showed a positive reaction. The remaining flasks of milk were sterilized. To one of the sterilized flasks of milk M/20 calcium acetate was now added until the milk just showed a positive reaction to the alcohol test. Since some of the calcium had been precipitated by the sterilizing process, this heated milk required more M/20 calcium acetate to make it positive. The difference in the amounts of M/20 calcium acetate necessary to cause a positive reaction in the raw and in the sterilized milk indicated how much calcium to add to bring the milk to the original position relative to the coagulating point. This amount of sterilized M/20 calcium acetate was then added to each of the remaining flasks of milk. Each flask was inoculated with a pure culture of a rennet forming organism and then incubated at 37°C. The milk was tested at definite intervals, and when the first positive test was obtained, the milk was plated on lactose agar to determine the bacterial count. The results are given in table 8.

TABLE 8

Influence of rennet of bacterial origin

SAMPLE	AMOUNT OF MILK	M/20 Ca ACETATE ADDED TO FRESH MILK	M/20 Ca ACETATE ADDED TO STERILIZED MILK	DIFFERENCE IN AMOUNT OF Ca ACETATE	BACTERIA COUNTS
	cc	cc	cc		
1	200	3.2	8.8	5.6	700,000 760,000
2	200	3.2	8.8	5.6	500,000 700,000
3	200	3.2	8.8	5.6	980,000 1,000,000
4	200	4.8	8.0	3.2	800,000 690,000
5	200	4.8	8.0	3.2	1,100,000 970,000
6	200	4.8	8.0	3.2	780,000 990,000
Average . . .	200	4.0	8.4	4.4	855,830

An average of six samples shows the bacterial count to be 855,830 per cubic centimeter. These results demonstrate that the rennet forming organisms are of greater importance than the results of Ayers and Johnson (8) indicated. However, it is only in exceptional cases that the number of rennet forming organisms present in milk approaches even the above figure; so that we must conclude that the rennet forming organisms are a minor factor in the alcohol coagulation.

DISCUSSION

The adherents to the alcohol test claim that it depends upon factors all of which give undesirable characteristics to the milk, such as: (*a*) acidity, (*b*) colostrum milk, (*c*) diseased udders, (*d*) diseased cows, etc. This had generally led to the belief that a positive test invariably indicates that such milk is undesirable and should be discarded. The question arises as to whether or not all milk discarded on the basis of the alcohol test is really undesirable milk. On the basis of the results of this investigation the question would have to be answered in the negative.

TABLE 9

Summary of factors influencing the alcohol test

FACTOR	EFFECT ON THE QUALITY OF THE MILK	ELIMINATION OF THESE FACTORS BY FARMER
Salt balance	Not undesirable	Cannot be eliminated
Acidity	Undesirable	Can be eliminated
Rennet forming organisms	Undesirable	Can be eliminated
Colostrum	Undesirable	Can be eliminated
Diseased udders	Undesirable	Can be eliminated
Diseased cows	Undesirable	Can be eliminated

Our present knowledge of the alcohol test will warrant the tabulation of factors as shown in table 9. In this table, for the sake of discussion, we may enumerate such factors as colostrum, diseased udders, and diseased cows, although these are not direct factors, but are effective only in so far as they alter the chemical composition of the milk.

In table 9 the salt balance causing a positive alcohol test is listed as "not undesirable." This statement needs modification in the case of milk to be used in the manufacture of evaporated milk. By a comparison of the effect of the salts on the alcohol coagulation as shown by this study, and their effect on the heat coagulation as found by Sommer and Hart (11) it is seen that both the alcohol and the heat coagulation are produced by an excess of calcium and magnesium over citrates and phosphates. The results of these two independent studies indicate that the alcohol test may be helpful in detecting the milk which causes the troublesome heat coagulation in the sterilization of the evaporated milk. This conclusion is in harmony with the conclusion of Dahlberg and Garner (12) that milk giving a positive alcohol test when concentrated into evaporated milk will coagulate more readily than alcohol negative milk. Therefore from the standpoint of evaporated milk manufacture the salt balance might have to be listed as "undesirable" in table 9. However, since the salt composition of the milk is not under the control of the producer, it is questionable whether a test of this kind would be just to the producer.

Although there are no direct observations available to show to what extent the milk salts are responsible for the positive alcohol test as applied to market milk, we can readily draw a conclusion as to the importance of the milk salts by comparing the normal variations in the milk salts with the amounts found effective in causing a positive test.

Sommer and Hart (11) in an analysis of thirty samples of milk found the CaO content to vary from 0.132 to 0.210 per cent; the MgO content from 0.019 to 0.029 per cent; the P_2O_5 content from 0.193 to 0.294 per cent and the citric acid content from 0.100 to 0.292 per cent. In this investigation it was found that an increase of 0.0112 per cent CaO (table 1), and 0.0040 per cent MgO (table 1) caused a positive test and that an increase of 0.00068 to 0.00884 per cent in P_2O_5 (table 4), changed a positive test to negative.

If we assume that M/20 sodium citrate is equivalent to M/20 potassium phosphate then the amounts of P_2O_5 given above are equivalent to 0.00096 to 0.0038 per cent citric acid. From table 2 it is seen that sodium citrate in equivalent amounts is even more effective than potassium phosphate, so that the figures for citric acid are maximum figures. These figures make it quite apparent that the salt composition undoubedly is the determining factor in many cases.

This is further emphasized by the results given in table 5. The acidity at which the sample of milk was positive varied from 0.20 to 0.30 per cent according to a slight variation in the salt composition.

From table 9 we can readily see that the alcohol test would be desirable because it rejects milk which is positive because of the last five factors mentioned. These five factors give undesirable qualities to the milk and are under the control of the producer, therefore, the alcohol test would be desirable if it detected these factors alone.

However, the alcohol test is also influenced very markedly by the salt composition of the milk; and a salt composition which may cause a positive alcohol test is neither undesirable (except in evaporated milk) nor under the control of the producer. Since this factor is undoubtedly the determining factor in the alcohol test, in many cases, the test must be regarded as ineffective and unjust, except possibly as applied to milk to be manufactured into evaporated milk. A further study of the application of the alcohol test to the manufacture of evaporated milk is in progress in this laboratory.

SUMMARY

1. A slight increase in the magnesium or calcium content will cause a positive alcohol test; an increase of potassium, sodium, chloride, citrate, and phosphate, will not cause a positive alcohol test.
2. The effect of the calcium and magnesium on the alcohol test is counteracted by the citrates and phosphates in the milk. A positive test with fresh milk depends mainly upon the relative amounts of these four salts present in it.
3. A high calcium content in a ration fed to cows can cause coagulation of milk in the alcohol test.
4. The effect of milk salts is of such importance that it can easily account for any lack of correlation between the alcohol test, acidity, and bacterial counts. The effect of acidity and the milk salts are additive.

5. Prepared rennet will cause a positive reaction in the alcohol test. The degree to which a sample of milk becomes positive will depend on the amount of rennet and the time it is allowed to act.

6. The coagulating enzymes produced by rennet forming organisms, numbering 856,000 per cubic centimeter are sufficient to cause a positive alcohol test. However, rennet forming organisms must be regarded as a minor factor in the alcohol test for their prevalence in milk rarely approaches this figure.

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SEASONAL VARIATIONS IN MILK AND FAT PRODUCTION

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In a previous paper (1) the seasonal variations of the percent of fat in cow's milk was presented. The object of this paper is to present the results of a study of the seasonal variations in milk and fat production using the records of the same cows.

The decrease in production due to the advance of the stage of lactation has been shown by Cooke (2), Linfield (3), Woll (4), and Grady (5). Cooke found that cows calving in the fall were more persistent than those calving in the spring. Woll concluded that there was little difference in the rate of decline of the various breeds. Eckles (6), studied the rate of decline of cows freshening every twelve months. Haecker (7) and Gavin (8) made studies to determine the length of time after calving that maximum production was attained.

The favorable influence of spring pasture on milk production has been shown by Cooke (2), Linfield (3), Grady (5), Hills (9), Otis (10), and Humphrey and Woll (11).

The effect on milk and fat production of spring and fall freshening has been shown by McCandlish (12), McDowell (13) and Moore (14). Fall freshening in each case favored increased milk and fat production.

The records of each breed[1] were divided into groups according to the month during which the lactation began, i.e., all cows calving in January were placed together, those in February together, etc. Records made during parts of two lactation periods were eliminated. The average monthly milk production for each month was obtained by totaling the production of milk and dividing this total by the number of cows in the group. For the sake of uniformity, all records were then converted to a thirty-day month and the average daily milk production obtained.

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[1] The data for the Guernsey cows were obtained from 3215 Advanced Registry records from eastern and middle western states with a sprinkling from the Pacific Coast states. Values for the Jersey cows were obtained on 305 Register of Merit animals in Missouri. The Holstein data were compiled from 95 Advanced Registry records on animals in the University of Missouri dairy herd.

As a basis of comparison, the influence of the stage of lactation on the average daily milk production of dairy cattle is presented in table 1.

TABLE 1

Influence of the stage of lactation on the average daily production of dairy cattle

MONTH OF LACTATION	GUERNSEY (3215 LACTATIONS)		JERSEY (305 LACTATIONS)		HOLSTEIN (95 LACTATIONS)	
	Milk daily	Per cent of total	Milk daily	Per cent of total	Milk daily	Per cent of total
	pounds		*pounds*		*pounds*	
1	33.3	10.6	30.0	10.9	39.6	10.4
2	34.3	10.9	29.4	10.6	40.3	10.6
3	32.3	10.3	27.9	10.1	38.9	10.2
4	29.9	9.5	25.9	9.4	36.5	9.6
5	28.1	8.9	24.2	8.8	33.9	8.9
6	26.4	8.4	22.7	8.2	32.5	8.5
7	24.9	7.9	21.4	7.7	30.8	8.1
8	23.7	7.5	20.6	7.5	29.3	7.7
9	22.4	7.1	19.5	7.1	27.9	7.3
10	21.0	6.6	18.6	6.7	25.4	6.7
11	19.5	6.2	17.3	6.2	23.2	6.1
12	17.9	5.7	17.3	6.2	20.1	5.3

An examination of table 1 reveals the fact that the decrease in milk production for the three breeds included, is remarkably uniform. In the case of the Guernsey and Holstein-Friesian breeds the highest average milk production is reached the second month, followed by a very slow gradual decline. The Jerseys, however, reached their maximum the first month and then declined slowly in close agreement with the other breeds. It will be noted that the average daily production the twelfth month is very close to 50 per cent of the production the best month. As compared to the data collected by Eckles (6) it will be seen that cows on test will hold up their production if forced methods are employed and a 365 day record is desired as compared to cows freshening every twelve months.

By grouping the records according to the month during which the lactation began, the influence of the stage of lactation as a factor influencing milk production can be shown in conjunction with seasonal or other variations.

The data for the Guernsey breed is presented in chart 1. The continuous lines in the charts are the plotted values showing the influence of the stage of lactation on the average daily milk production as shown in table 1 while the columns are the plotted values obtained for the cows grouped according to the month during which the lactation began showing the average production of milk throughout the lactation period. The group of Guernsey cows starting their lactation periods from January to June follow the average figures very closely. The July group decreased in production the second month as compared to the first, probably due to the poor feeding conditions on pasture as well as heat and flies. The low average production of cows calving in August is very noticeable. They run below the average for almost the entire lactation period. The cows calving in the fall from September to December again follow the average fairly closely until the following spring when the production is slightly above the average. This is attributed to the favorable influence of spring pasture. It should be observed, however, that in no case does the milk production actually increase during the spring months. The following explanation is given. Cows on test are generally being forced with an abundance of feed and do not respond to pasture as much as cows receiving only ordinary care, in fact it has been observed that some test cows will actually decrease in milk production when turned on pasture. Another possible explanation may lie in the wide geographical distribution of the cows. The difference in the time when cows were turned to pasture would tend to counter balance each other.

From the standpoint of total milk production, it will be seen that the cows calving in the fall and winter months equal or exceed the average production while those calving during the summer months are below the average.

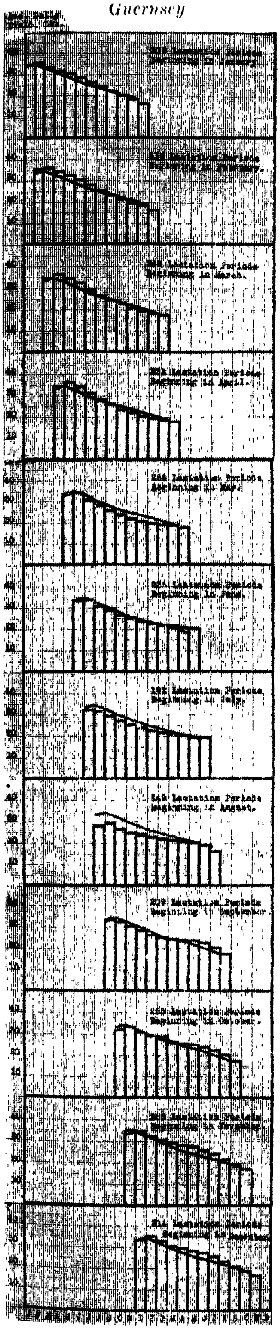

Chart 1

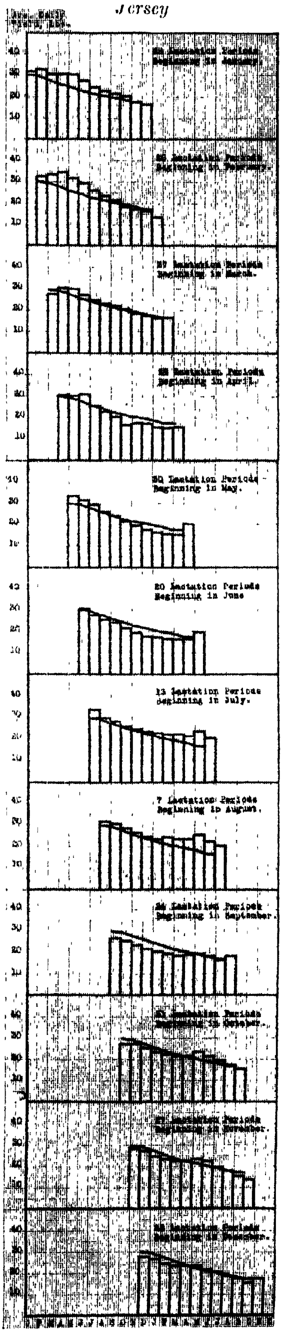

Chart 2

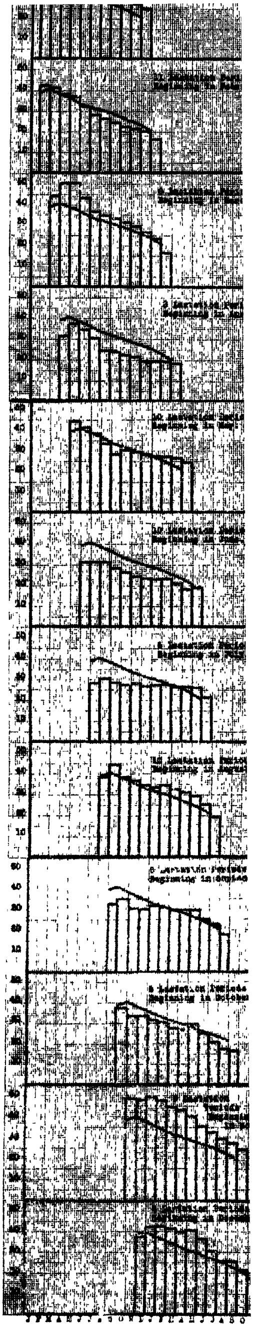

Chart 3

Influence of the Season of the Year on the Yield of Milk

The data for the Jersey breed is presented in chart 2. The groups of cows starting their lactation period in January, February, and March increase in production the second month while those starting during the rest of the year reach their maximum the first month. The favorable effect of pasture is also very noticeable as in practically every case the production of milk increases in May irrespective of the length of the lactation period.

The data for the Holstein-Friesian breed is presented in chart 3. As the number of cows is limited individual variations have not been eliminated. Some significance, however, may be attached to the relatively low production of those cows calving during June and July. The effect of pasture is also shown by the increased milk production during May.

TABLE 2

Influence of the season of the year on the yearly production of dairy cows

Based on a thirty-day month

MONTH LACTATION STARTED	GUERNSEY YEARLY PRODUCTION		JERSEY YEARLY PRODUCTION		HOLSTEIN FRIESIAN YEARLY PRODUCTION	
	Milk	Fat	Milk	Fat	Milk	Fat
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
January	9,726	482.8	9,213	480.8	13,683	415.9
February	9,723	485.9	8,913	469.8	10,617	337.8
March	9,642	479.5	8,325	428.9	12,675	398.4
April	9,492	474.2	7,779	418.5	9,039	292.4
May	8,973	462.1	8,121	435.9	12,315	356.5
June	9,384	476.8	7,584	400.4	9,147	279.7
July	9,300	159.0	8,949	445.8	9,828	338.8
August	8,466	429.1	9,126	497.2	11,997	363.6
September	9,414	475.4	7,461	408.5	10,401	322.4
October	9,615	478.2	7,983	417.4	9,924	300.4
November	9,918	494.4	7,884	424.7	11,577	461.4
December	9,645	485.1	7,824	424.8	12,420	373.9

The influence of the season of the year on the yearly production of dairy cows is shown in table 2. With some minor exceptions, the best milk and fat records are made by cows calving during the months from September to April. Probably due to the forced feeding methods employed with cows on official test, there is not as much difference as might be expected.

SUMMARY

Data was presented showing that the average monthly decrease in milk production for all breeds is very uniform, the production during the twelfth month being approximately 50 per cent of the production during the best month.

The principal variations in milk production, aside from that due to the advance of lactation, were found to be largely due to the changes in pasture during the spring and summer months. The fundamental reason for the variation in milk is probably one of nutrition. This in turn being affected to some extent by atmospheric temperature. Cows on test being well fed are probably less affected, either favorably or unfavorably, by pasture than those not being pushed for maximum production.

From the standpoint of total milk production, cows calving in the fall and winter months equal or exceed the average production while those calving during the summer months are generally below the average.

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A STUDY OF THE USE OF SUPERHEATED AND UNSUPERHEATED PLAIN CONDENSED BULK SKIM MILK IN THE MANUFACTURE OF ICE CREAM[1]

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INTRODUCTION

Plain condensed bulk milk is a product made from either whole, partly whole, or skim milk and is used for the most part to supply the necessary solids in the manufacture of ice cream.

Superheated plain condensed bulk skim milk is the unsweetened condensed milk made from completely skimmed whole milk condensed in vacuo at the ratio of about three parts of fluid milk to one part of condensed milk, followed by heating to a temperature from 180° to 190°F. and holding at that temperature for a sufficient length of time to give the body of the condensed milk a heavy consistency. The product is not sterile.

The same definition holds for the unsuperheated condensed skim milk except that the latter is not subjected to a high temperature to thicken it. Like the superheated condensed skim milk, it is not a sterile product.

USE OF CONDENSED MILK IN ICE CREAM MAKING

Condensed milk is used in ice cream making as a source of milk solids not fat. Since a considerable portion of the excess water has been removed, it is possible to combine condensed milk, cream, sugar and gelatin in such proportions that the resulting mixture will have the desired percentages of butter fat, milk solids not fat, sucrose and gelatin. Without the use of a milk product from which a large part of the water had been removed, it would be impossible to obtain an ice cream mix sufficiently high in milk solids not fat to insure a desirable body in the finished product.

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[1] This article is based upon the thesis presented to the Faculty of the Graduate School of the University of Illinois by P. H. Tracy in partial fulfillment of the requirements for the Degree of Master of Science in Dairy Husbandry. The experimental work was completed in June, 1922. A typewritten copy of the original thesis will be found in the files of the Library of the University of Illinois.

The work was done under the supervision of Profs. O. R. Overman and H. A. Ruehe of the Department of Dairy Husbandry, University of Illinois.

In most cases the plain bulk condensed milk used in ice cream making has been superheated. This process consists in heating the condensed milk to a temperature ranging from 180° to 190°F. by the introduction of live steam before the milk is drawn from the vacuum pan, but after it has been evaporated to the desired concentration of solids. Since the superheating causes the condensed milk to thicken, the resulting product is thought to be more desirable for ice cream making, the current belief being that it improves the body of the ice cream. Lack of definite information on that point was the incentive for this investigation.

THE OBJECT OF THE INVESTIGATION

The purpose of this investigation was to make a comparative study of superheated and unsuperheated condensed skim milk with particular reference to their use in ice cream making. An attempt was made to obtain information relative to the following points:

1. The effect of superheating upon the physical state of the milk proteins.

2. The effect of the use of superheated and unsuperheated condensed skim milk upon each of the following:

a. The viscosity of the ice cream mix

b. The finished product: (*1*) Over-run, (*2*) body, (*3*) texture, (*4*) resistance, (*5*) flavor, (*6*) heat resistance.

PLAN OF WORK

The folowing general plan of procedure was used in securing the data.

Preparation and study of the condensed milk[2]

Ordinary separator skimmed milk was used in the manufacture of the condensed milk. The milk was first placed in a large open vat, commonly called the forewarmer, having a capacity of 200 to 220 gallons, and heated to about 150°F. by the introduction of live steam. It was then drawn into a 3-foot vacuum pan of the C. E. Rogers type, where the excess water was removed by boiling at a temperature of about 130°F. with about a 24-inch vacuum. Heat was supplied by means of a steam coil jacket and the necessary vacuum was obtained by means of a small steam pump.

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[2] Throughout the remainder of this article, the term "condensed milk" will be taken to mean "plain condensed bulk skim milk."

After the milk had been concentrated to about 12.5° Baumé at 130°F., 15 or 20 gallons were drawn from the pan to be used for comparative study with the superheated condensed. The remainder was then superheated by forcing in live steam until a temperature of 185° to 190°F. was reached. It was held at that temperature until it had thickened to the desired consistency. The amount of time required for the superheating varied from five to fifteen minutes. The milk was then cooled by maintaining a partial vacuum in the condenser. As soon as the temperature dropped to about 130°F. the milk was drawn into 10-gallon milk cans, and the temperature was further reduced by placing the cans in a large tank and surrounding them with running cold water.

The total solids content of both the superheated and the unsuperheated condensed milk was then determined, and enough water was added to standardize each to 27 per cent total solids.

The relative viscosity of the condensed milk was determined to show the physical effect of superheating upon the body of the condensed milk.

To determine the cause of the difference in viscosity, samples of both the superheated and the unsuperheated condensed milk, after being diluted with about twice their volume of water, were filtered by suction through porous clay filters of the Berkefeld type. The filtrates were then tested for casein and albumin.

The preparation of the mixes

With the exception of the first eight batches (which were half the size of the others) each of the mixes made had a total weight of approximately 50 pounds, which was sufficient to make 8 to 10 gallons of ice cream. Forty per cent cream, skim milk, 27 per cent bulk condensed skim milk, sugar, gelatin, water, and vanilla extract were the only ingredients used. The percentages of fat and solids not fat varied in the different mixes, as shown in the table, but the amount of sugar, flavoring and gelatin used was constant in each batch. The weighing was done on a 10-pound spring scale graduated to ounces.

TABLE 1

Composition of the mixes

BATCH* NUMBER	FAT	M.S.N F	SUGAR	GELATIN	T S	40 PER CENT CREAM	SKIM MILK	27 PER CENT CONDENSED MILK	WATER	TOTAL WEIGHT†
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*pounds*	*pounds*	*pounds*	*pounds*	
1 and 100	8.07	10.10	11.93	0.5	30.50	10.0	22.9	8.9	2	50.30
2 and 200	8.11	13.92	11.93	0.5	34.37	10.0	11.8	20.0	2	50.30
3 and 300	8.29	17.85	12.10	0.5	38.65	10.0		31.1	2	49.60
4 and 400	10.08	10.04	11.98	0.5	32.51	12.5	19.8	9.3	2	50.10
5 and 500	10.10	13.82	11.93	0.5	36.26	12.5	9.0	20.3	2	50.30
6 and 600	12.03	10.02	11.93	0.5	34.39	15.0	17.0	9.8	2	50.30
7 and 700	12.09	13.82	11.93	0.5	38.25	15.0	5.9	20.9	2	50.30
8 and 800	14.02	9.92	11.93	0.5	36.28	17.5	14.2	10.1	2	50.30
9 and 900	8.10	12.00	11.94	0.5	32.65	10.0	17.0	14.5	2.25	50.25
10 and 1000	10.09	11.96	11.94	0.5	34.41	12.5	14.0	15.0	2.25	50.25
11 and 1100	12.06	11.92	11.94	0.5	36.34	15.0	11.0	15.5	2.25	50.25
12 and 1200	14.05	11.92	11.94	0.5	38.33	17.5	8.0	16.0	2.25	50.25

* Batches 1 through 12 refer to those batches containing superheated condensed milk, while nos. 100 through 1200 refer to the comparable batches containing unsuperheated condensed milk.

† Each of the mixes contained 6 pounds of sugar, 4 ounces of gelatin and 4 ounces of vanilla.

Ordinarily from 8 to 16 different batches were run at one time, half of which were made with superheated and half with unsuperheated condensed milk. With the exception of the condensed milk, the same ingredients were used in all the mixes made at the same time. This, in addition to the fact that the same freezer was used for all and that the temperature of the brine remained fairly constant during one day's freezing, furnished a just basis for a comparative study of the use of superheated and unsuperheated condensed milk in ice cream making.

Table 1 gives the composition and amounts of the different ingredients used in each batch.

Method of determining viscosity

An ordinary 17.6 cc. milk pipette was used in determining the relative viscosity of the ice cream mixes and of the condensed milk. Two different pipettes were used. Due to its extreme visocity, it was necessary to use a pipette with a comparatively large opening to measure the viscosity of the superheated condensed milk. For the unsuperheated condensed milk and the ice cream mixes a pipette with a smaller opening at the discharge end was satisfactory.

In order that all the readings might be reduced to the same basis, the time of discharge of the substance expressed in seconds was in each case divided by the time of discharge of distilled water at the same temperature. The result was termed the relative viscosity.

The liquid to be measured was first tempered to 20°C. It was then drawn into the pipette, which was marked at the top and bottom of the enlarged portion. The time required for the top of the column to pass from the upper to the lower of these graduations was then determined with a stop watch. While it was emptying, the pipette was held in a vertical position in a ring stand. It was thoroughly cleaned and dried between operations by means of hot water, alcohol and ether. The temperature of the room was kept as near 20°C. as possible.

Since it was found that duplicate runs resulted in very close checks, single runs were used for mixes 1 through 8 in order to facilitate matters, as it was desirable to measure the viscosity the same day the batches were frozen. However, two runs were made on batches 9 through 12 and the averages of these were used in determining viscosity.

Method of freezing

The mixes were ususally aged for twenty-four hours before being frozen. An attempt was made to have the temperature of the mix not higher than 45°F. at the time it was placed in the freezer. A chain-driven 50-quart horizontal brine freezer was used to freeze the ice cream. In freezing batches 9 through 12 and 900 through 1200, the ice cream was allowed to whip until the maximum amount of air, as determined by the Mojonnier over-run tester, had been obtained. Batches 1 through 8 and 100 through 800 were drawn when the appearance of the ice cream warranted it. Both methods are used in commercial plants.

The freezer was thoroughly rinsed with water after each batch was drawn in order that the composition of the following mix might not be altered in any way.

Method of determining the over-run

The over-run on batches 1 through 8 and 100 through 800 was determined in the following manner. A one-half pint Seal-Right paper carton was weighed and then filled with the unfrozen mix and weighed again. It was next filled with the frozen ice cream, which in turn was weighed. The percentage of air that had been incorporated in the ice cream, or the over-run, was then determined by subtracting the net weight of the ice cream from the net weight of the mix, dividing the difference by the net weight of the ice cream and multiplying by 100.

The over-run on batches 9 through 12 and 900 through 1200 was obtained with the Mojonnier over-run tester.

Taking the samples

In order that the quality of the finished product might be determined, three samples were taken from each batch in small one-third pint cartons. These samples were always taken from the top of the first can drawn, which gave a fair representation of the whole batch. The samples were placed in a hardening room, which was kept at a temperature ranging from 11°F. to −4°F.

Judging the ice cream

The ice cream was removed from the hardening room at about seven day intervals and judged by Profs. H. A. Ruehe, O. R. Overman, and A. S. Ambrose of the Department of Dairy

Husbandry, together with the author. The criticisms on each batch were the summarized conclusion of this group of judges and were altogether of a comparative nature, as no attempt was made to use the score card.

Method of determining heat resistance

The difference in the ability of ice cream, differing only in the use of superheated and unsuperheated condensed milk, to withstand the influence of heat was determined by subjecting samples of comparative batches of ice cream to the same heat conditions and measuring the amount that melted and dropped off in a given time. Each batch was represented by triplicate samples.

For this purpose one-half pint and pint paper cartons were used. Since the amount of air incorporated might have some effect upon the rate of melting of the ice cream, samples having the same over-run (as determined by the Mojonnier over-run tester) were used in each comparison.

EXPERIMENTAL RESULTS

Effect of superheating upon the milk protein

The effect of superheating upon the relative viscosity of the condensed milk is shown by the following table. In the second column is given the viscosity of the condensed milk before it was superheated, while in the third column is given the viscosity of the same condensed milk after it had been superheated. In all cases the total solids content was standardized to 27 per cent.

SAMPLE NUMBER	BEFORE SUPERHEATING	AFTER SUPERHEATING
1	4.2	93.7
2	2.8	14.2
3	3 4	176.1
4	3.2	241.4
5	2.0	114.0
6	1.7	85.0
7	1.8	95.5
8	2.5	491.8

The extremely viscous condition of the condensed milk that exists after the superheating process has been completed is commonly referred to as the "liver," or coagulum. In a way these terms suggest a possible explanation of what happens when condensed milk is superheated, but a more definite explanation is lacking.

From a study of the properties of the butterfat, milk sugar and ash content of milk, it is thought that heating these substances to a temperature of 190°F. would not be responsible for the increased viscosity of the condensed milk. If this is true, it necessarily follows that the increased viscosity of the condensed milk brought about by superheating is due to a change in the physical form of the milk proteins. This was proven by filtering both superheated and unsuperheated condensed milk through porous clay filters and analyzing the filtrate for both casein and albumin.

The milk was first thoroughly mixed with twice its volume of water and then placed in porous clay filters of the Berkefeld type. A colorless filtrate was secured by applying suction to the clay plate.

In case of the superheated condensed milk this filtrate contained no protein. The filtrate of the unsuperheated condensed milk, however, gave very pronounced reactions with the protein tests used. The following tests for protein were used:

1. Xanthoproteic reaction
2. Millon's reaction
3. Biuret reaction

The filtrate from the unsuperheated condensed milk was further analyzed for casein and albumin. About 50 cc. of the filtrate was first made neutral with dilute sodium hydroxide. Dilute hydrochloric acid was then added a few drops at a time until 1.5 cc. had been added. The filtrate was allowed to stand a few minutes, but no precipitate was formed, indicating the absence of casein. Another portion of the filtrate was then boiled until a floculent precipitate was obtained, indicating the presence of albumin.

The high degree of viscosity that occurs in superheated condensed milk may be explained by the fact that the superheating changes the ablumin from a colloidal to a finely divided precipitated form. In this state it is possible that the albumin particles adsorb not only each other but the casein as well, producing an effect not unlike an emulsion, the albumin in this case being the dispersed phase.

The effect of the use of superheated and unsuperheated condensed milk upon the ice cream

To determine the effect of the use of superheated condensed milk upon the ice cream, comparative criticisms were made of the various lots of ice cream containing superheated condensed milk with those containing unsuperheated condensed milk. Twelve different combinations of fat and milk solids not fat were represented. Each of the 80 different batches were judged three times, making in all 240 criticisms.

The data obtained show conclusively that the use of superheated condensed milk causes the ice cream to have a better body and a smoother texture and also increases the amount of resistance. On the other hand, ice cream containing unsuperheated condensed milk is not so likely to develop an old or condensed milk taste upon being held in storage and has a superior flavor even when fresh, due to the fact that the fresh milk flavor of the unsuperheated condensed milk has not been destroyed by heating to a high temperature.

Since superheating causes a change in the physical state of the milk proteins, it might be expected that the use of superheated condensed milk would be a contributory factor to the development of sandiness in the ice cream. However, the data indicate that there is no appreciable difference in the tendency which comparable batches have to become sandy.

Since the greatest amount of condensed milk was used in those batches having the highest percentage of milk solids not fat, it might be expected that those batches would show the greatest effect of the use of superheated condensed milk. However, the converse was true, for the greatest difference was in those batches containing a low percentage of milk solids not fat and in which only 9 or 10 pounds of condensed milk were used. This can be explained by the fact that the addition of a slight amount of solids is more noticeable up to a certain point than it is beyond that point. Consequently, the addition of a few more solid particles to those mixes containing from 30 to 33 per cent total solids would seem to have a greater effect upon the texture, resistance and body of the ice cream than the addition of two or three times as many particles to those mixes containing from 35 to 38 per cent total solids.

The data also show that it is possible for the use of unsuperheated condensed milk to result in a better ice cream than that made with superheated condensed milk. Referring to batches 3 and 5, due to the high solids content, neither the body, texture, nor resistance of the ice cream was as desirable as that of the comparable batches containing unsuperheated condensed milk. By way of explanation, it may be said that the percentage of total solids in these batches was probably such that the addition of any more solid particles subtracted from, rather than added to, the merits of the ice cream.

It was the opinion of the judges that in general the use of the superheated condensed milk was equivalent to the addition of about 2 per cent solids. For example, it was noted that batch 1200, containing unsuperheated condensed milk and having 38.33 per cent total solids, was comparable to batch 11, which contained superheated condensed milk and had a 36.34 per cent total solids content. Also, batch 1100 (containing unsuperheated condensed milk) seemed to have about the same texture and resistance as batch 10 (containing superheated condensed milk), which contained 2 per cent less total solids.

Effect of the use of superheated condensed milk upon the viscosity of the ice cream mix

Since superheating results in a marked increase in the viscosity of the condensed milk, it is to be expected that an ice cream mix containing superheated condensed milk will have a greater viscosity than that in which concentrated skim milk is used.

This difference is shown in the following graphs of the average viscosity of three series each of batches 1 through 12, and 100 through 1200.

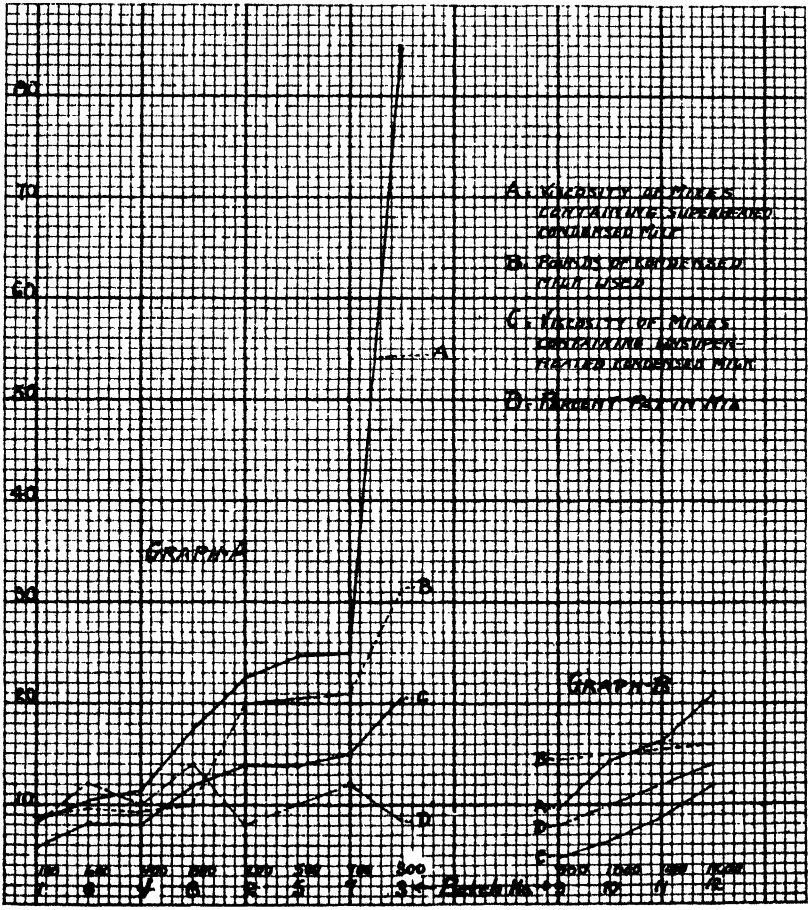


FIG. 1. GRAPHS SHOWING THE EFFECT UPON THE VISCOSITY OF THE MIX OF THE USE OF SUPERHEATED CONDENSED MILK, AS WELL AS THE RELATION BETWEEN VISCOSITY, THE AMOUNT OF CONDENSED MILK USED AND THE PER CENT OF BUTTERFAT IN THE MIX

The graphs in figure 1, in addition to showing the difference in the average viscosities of the batches also show the relation between the viscosity, the amount of condensed milk used, and the percentage of butterfat in the mix.

Graph A plainly shows the increase in viscosity due to the use of superheated condensed milk and indicates that as the amount of condensed milk used was increased the viscosity of the mix also increased, the amount of increase being modified somewhat by the percentage of butterfat. However, the greater increase was due to the percentage of milk solids not fat and the amount of condensed milk used. This is shown by the increase in viscosity of batches 5 and 500 and batches 3 and 300 over batches 8 and 800 and 7 and 700 respectively. In both cases the percentage of milk solids was the same; however, those containing the greater percentage of milk solids not fat (which also contained the greater amount of condensed milk) had the greater viscosity.

Graph B also shows how the increase in percentage of fat and the amount of condensed milk used causes an increase in the viscosity of the mix. Since the percentage of milk solids not fat was constant, while the percentage of fat increased with each batch, the increase in viscosity in this case was mostly due to the increased amount of butterfat present, as there was only a slight increase in the amount of condensed milk used.

Effect of the use of superheated condensed milk upon the over-run obtained

Since ice cream mixes containing superheated condensed milk have a greater viscosity than those containing unsuperheated condensed milk, it is to be expected that the ice cream made from the former will have a higher percentage of over-run than that made from the latter. That such is the case is shown by the comparison of the average over-run obtained on two series each of 12 batches containing superheated condensed milk and 12 batches containing unsuperheated condensed milk, as given in table 2.

The ice cream represented in Part I of table 2 was drawn from the freezer when it appeared to have been frozen sufficiently. This is the method commonly used in commercial practice. There are plants, however, where the ice cream is not drawn until a maximum over-run is obtained. This was the method followed in securing the data given in Part II.

It will be noted that in practically all cases a greater over-run was obtained from those mixes containing superheated condensed milk than from those containing unsuperheated condensed milk.

Effect of the use of superheated condensed milk upon the heat resistance of the ice cream

The relation existing between the heat resistance of ice cream containing superheated condensed milk and that containing unsuperheated condensed milk is shown in table 3.

TABLE 2

Effect of the use of superheated condensed milk upon the over-run obtained

BATCH NUMBER (SUPERHEATED)	OVER-RUN	BATCH NUMBER (UNSUPERHEATED)	OVER-RUN
	Part I		
1	85.7	100	73.4
2	86 3	200	90.5
3	83.0	300	70.0
4	83.8	400	74.9
5	73.5	500	58 5
6	84.2	600	68.4
7	80.6	700	67.8
8	78 0	800	56.9
	Part II		
9	78.7	900	72 3
10	81.0	1000	74.7
11	81.7	1100	71.7
12	84.3	1200	74.3

It is evident from these data that ice cream containing superheated condensed milk will stand up much better when subjected to a temperature above freezing than will that in which unsuperheated condensed milk is used, the amount of difference depending upon the quantity of condensed milk used.

The difference in the way in which comparative batches of ice cream melted is also shown in the following pictures taken of samples 16a, 17a and 18a recorded in table 3. Picture 1 represents the appearance of the samples at the start of the experiment.

Picture 2, taken of the samples at the end of one hour, clearly shows how the increase in the amount of superheated condensed milk used increases the ability of the ice cream to stand up. The composition of all three batches was the same, the only difference being the condensed milk used. In the sample on the left 9.3 pounds of unsuperheated condensed milk were used; in the middle sample 9.3 pounds of superheated condensed milk were used; while

TABLE 3

Difference in melting of ice cream made from superheated and unsuperheated condensed milk

NUMBER	WEIGHT			MELTED		TEMPERATURE	OVER-RUN
	At start	After one hour	After two hours	After one hour	After two hours		
	grams	*grams*	*grams*	*per cent*	*per cent*	*°C.*	*per cent*
*16 a	250	237	125	5.2	50.0	20.5	70
*16 b	253	238	133	5.9	47.8	20.5	70
*16 c	249	235	121	5.6	59.4	20.5	70
Average	250.7	236.7	126.3	5.6	49.7		
†17 a	246	236	144	4.1	41.7	20.5	70
†17 b	240	231	138	3.8	42.5	20.5	70
†17 c	238	230	129	3.4	45.8	20.5	70
Average	241.3	232.3	137	3.7	43.3		
†18 a	235	235	159.5	0	32.1	20.5	70
†18 b	242	242	168	0	30.6	20.5	70
†18 c	238	238	173	0	27.3	20.5	70
Average	238.3	238.3	166.8	0	30.0		

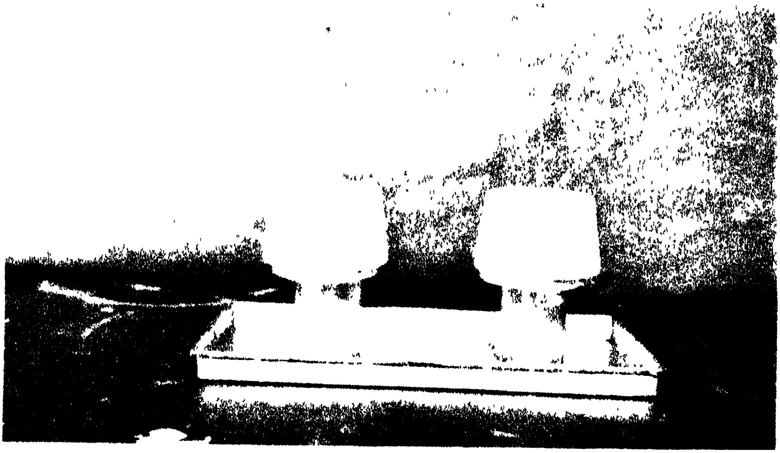
Composition of mixes in table 3

NUMBER	FAT	M S N F	SUGAR	GELATIN	T S	40 PER CENT CREAM	SKIM	CONDENSED	WATER
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*pounds*	*pounds*	*pounds*	*pounds*
*16: a, b, c	10	10	12	0.5	32.5	12.5	19.8	9.3	2.00
†17: a, b, c	10	10	12	0.5	32.5	12.5	19.8	9.3	2.00
†18: a, b, c	10	10	12	0.5	32.5	12.5		15.9	15.35

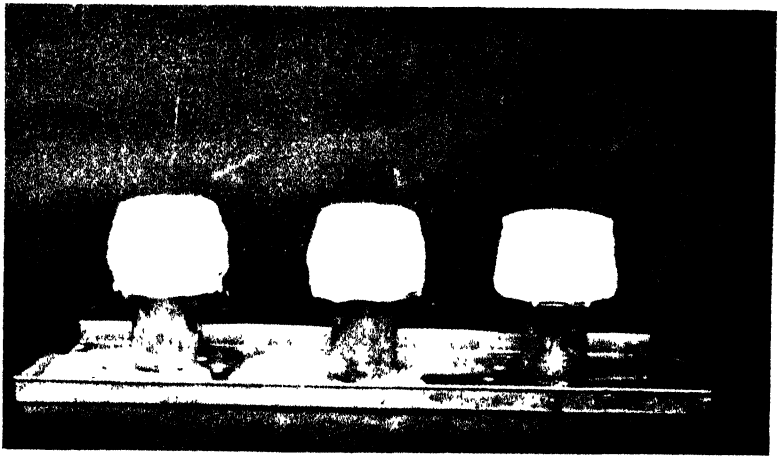
* Unsuperheated condensed milk was used.

† Superheated condensed milk was used.

in the third sample 15.9 pounds of superheated condensed milk were used. The difference in the percentage melted from the first



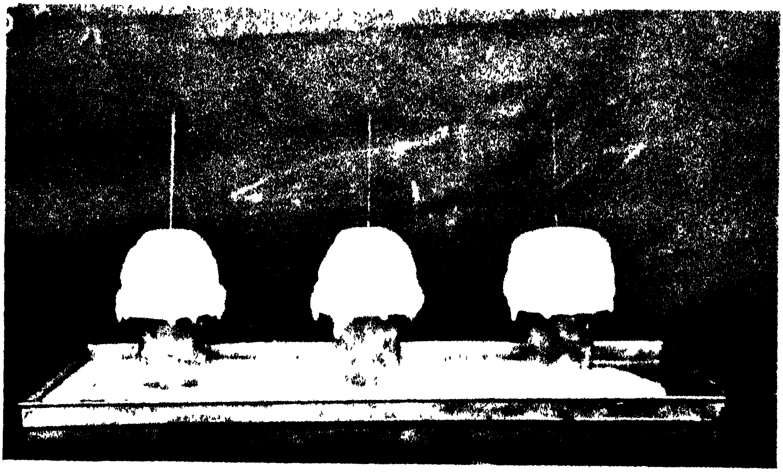
PICTURE 1. APPEARANCE OF ALL THE SAMPLES BEFORE EXPOSURE TO ROOM TEMPERATURE



PICTURE 2. APPEARANCE OF THE SAMPLES AFTER ONE HOUR'S EXPOSURE TO ROOM TEMPERATURE

two samples is hardly noticeable, being 1.1 per cent. However, the difference between either the first or second and the third is more striking. The percentage melted in the first case was 5.2; in the second, 4.1; whereas only three drops had fallen from the third sample when the picture was taken.

Picture 3 shows samples 16a, 17a and 18a at the end of two hours. The appearance of samples 16a (left) and 17a (center) is about the same, the difference in the percentage melted being 8.3. When sample 16a and 18a (right) are compared, however, a greater difference can be seen, the difference in the percentage melted being 17.9.



PICTURE 3. APPEARANCE OF THE SAMPLES AFTER TWO HOURS' EXPOSURE TO ROOM TEMPERATURE

Both the data and the pictures show rather conclusively that the use of superheated condensed milk causes the ice cream to have more resistance to temperatures above the freezing point, the ice cream having the greatest resistance being that containing the largest amount of the superheated condensed milk.

CONCLUSIONS

1. Superheating condensed skim milk causes the albumin to be changed from a colloidal to a precipitated form.
2. The use of superheated condensed milk increases the viscosity of the ice cream mix.

3. The use of superheated condensed milk improves the texture and body of the ice cream and increases its resistance.

4. Ice cream containing unsuperheated condensed milk has a better flavor than that containing an equal amount of superheated condensed milk.

5. A larger over-run can be obtained from a mix containing superheated condensed milk than from a mix containing an equal amount of unsuperheated condensed milk.

6. An ice cream containing superheated condensed milk will have a greater heat resistance than that containing an equal amount of unsuperheated condensed milk.

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THE NUTRITIVE VALUE OF THE PROTEINS OF COCONUT MEAL, SOY BEANS, RICE BRAN AND CORN

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Undoubtedly the most systematic and scientific method of formulating the food requirements of farm animals is that of the late Dr. H. P. Armsby. The Armsby standards for the maintenance of farm animals, for their growth and fattening, and for the maintenance of milk production, are not in the main empirical, as are so many others, but are the result of a searching analysis of physiological functioning. While the experimental data upon which they are based are not always so complete as to make them in any sense final; while the interpretation of the data may not in all cases be above criticism; and while some of the standards are not as widely applicable as they are stated to be; nevertheless, the general method by which they are deduced and the terms in which they are expressed are so far superior to other methods and other terms as to put them in a class by themselves. The conception of "net energy" and the direct and indirect determinations of the net energy values of a large number of feeds of common use in this country, permits a wide application of the Armsby standards in American feeding practice, insofar as any feeding standard may be so applied to advantage.

In determining the energy requirements of animals for maintenance, the method of Armsby has been simply to determine experimentally the energy expenditure of the fasting, resting animal, at moderate external temperatures. An amount of net energy equal to this expenditure should maintain the animal. In determining the energy requirements for production, the actual energy content of the added tissue or of the milk secreted represents the net energy required, recognizing that the net energy value of feeds may vary with the type of production.

Unfortunately the determination of protein requirements is not so simple. While it seems to be a fact that the loss of nitrogen sustained by an animal on a ration containing sufficient energy but free from protein and other forms of nitrogen, is a measure of the protein minimum for the maintenance of life, it cannot be concluded that an equivalent amount of digestible protein will cover this requirement. Nor can it be said that the protein content of added tissue or the protein content of milk secreted measures directly the amount of digestible protein required for their elaboration. The reason is that there is a wastage of digestible protein in serving body purposes just as there is a wastage of digestible energy. While the latter wastage seems to be a physiological phenomenon, the former seems to be largely a chemical phenomenon, due to the difference in chemical structure between body proteins and food proteins. One seems to be as inevitable as the other, however.

Therefore, before a determination of the amount of food protein required for a certain purpose can be made, it is necessary to know not only the amount of protein the body needs, but also the inevitable wastage of food protein in covering this need. As is well known this wastage of protein differs rather widely among different forms of food protein, and any measure of the nutritive value of the protein of a given food must include not only the wastage due to incomplete digestibility, but also the wastage of digestible material representing the fragments of food protein (amino acids) left over in its conversion into body protein, or in its utilization in the "repair" of the body tissues. These left-over fragments, though available for the production of energy or even for the storing of energy, cannot be used for the covering of protein needs for the lack of proper supplementary fragments.

The simplest and the most serviceable method of measuring the nutritive value of digestible protein seems to be that of Karl Thomas[1]. The value of a protein according to this method (its so-called "biological value") is measured by the number of parts of body protein that may be spared by 100 parts of the digestible food protein in question. Thus, a value of 60 would mean that 1 pound of the digestible food protein would be required to cover a loss of 0.6 pound of body protein in the endogenous protein catabolism. In other words, if an animal loses 0.6 pound protein per day (urinary N × 6) on a protein-free ration containing sufficient energy, 1 pound of the digestible protein in question would be required daily for maintenance.

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[1] Thomas, Karl, Arch. Anat. und Physiol., Physiol. Abt., 1919, 219.

It seems probable that the same conception can be extended to cover the other functions of protein in the body besides that of replacing nitrogen degraded in the so-called "wear and tear" processes of metabolism, whatever these may be. For example, when the protein intake is sufficiently high to support growth, it may be found that 1 pound of the digestible protein in question may be required to form 0.7 pound of tissue protein. Hence, a coefficient of 70, entirely analogous to Thomas' "biological value" for maintenance, may be given to this protein. If the values of proteins for maintenance and for growth are not greatly different, the coefficient assigned to a protein may include all the structural purposes for which protein is used in the body, so that of every pound of digestible protein consumed, a more or less constant amount can be used for maintenance and growth. After considerable experimentation we have adopted this method of expressing the value of digestible protein in nutrition.[2]

By the use of these values of Thomas it would be possible to formulate protein requirements by the same method Armsby has used in formulating energy requirements, and to list the "net protein" value of feeds in the same way as their net energy values have been listed.

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[2] While it is probably true that all proteins have lower biological values for growth than for maintenance, our experience has shown that the level at which the protein is fed is probably of greater importance in most cases in determining its value to the body in satisfying nitrogen requirements than the purposes for which it is used in the body. In covering the maintenance requirement the biological value of a protein seems to be lower when fed at a 10 per cent level than when fed at a 5 per cent level, so that at the former level the difference in the values of the protein for maintenance and for growth is probably not great. While our experience with rations containing more than 10 per cent of protein is limited, such as it is it indicates that no marked further decrease in biological value need be expected until the level is so high that maximum growth is possible.

Few reliable determinations of the nutritive value of the protein of foods by the method of Thomas have been published to date. Nevens, working in this laboratory and using a method developed here after several years of work, has recently published[3] the results of some metabolism studies on rats designed to measure the value for maintenance and growth of the proteins of corn, alfalfa hay, and cottonseed meal, alone and combined in various ways. The work to be reported in this paper, extends this investigation to coconut meal, soy beans, and rice bran, and includes studies of combinations of these feeds with each other and with corn. Rats were the experimental subjects; and the technique of the collection of urine and feces was identical with that used and fully described by Nevens, as was also the method of calculating the nutritive value of the proteins.

THE LOSSES OF NITROGEN ON AN N-FREE RATION

The nitrogen loss from the body due to the constant disintegration of tissue in the course of the endogenous catabolism was determined by feeding the rats a nitrogen-free but otherwise adequate ration for ten days, and by measuring the losses of nitrogen in the urine for the last seven days of this period. The losses of nitrogen in the feces per gram of this ration consumed was taken as a measure of the so-called "metabolic nitrogen" of the feces, and was used in subsequent periods in the determination of the actual digestible nitrogen of the protein rations fed.

Such a nitrogen-free feeding period constituted the first and the last (the eighth) balance periods of the experiment. The data obtained are included in table 1.

For the first period on this ration the urinary nitrogen per day per 100 grams of body weight averaged 20.6 mgm. with only small variations among individual rats with the exception of rat 131. We take these values as measures of the endogenous

[3] Nevens, W. B., J. Dairy Science, 1921, vi, 552.

nitrogen excretions of the rats, representing losses that must be made good by dietary protein if the body weight is to be maintained. The daily fecal nitrogen on the nitrogen-free diet obviously has its origin in the body of the rat, and may be taken to represent the wastage of body nitrogen in digestion. It would seem to be related to the amount of food consumed and averaged 193 mgm. per 100 grams of food. Considerable individual variations appear in this value, which seems to be affected by factors not under control in our experiments, such as the consumption of filter paper, with which the bottoms of the metabolism dishes were covered.

TABLE 1

Metabolism of rats on a nitrogen-free ration

RAT NUMBER	PERIOD	INITIAL WEIGHT	FINAL WEIGHT	AVERAGE FEED CONSUMED DAILY	DAILY URINARY NITROGEN	DAILY FECAL NITROGEN	DAILY URINARY N PER 100 GRAMS LIVE WEIGHT	FECAL N PER 100 GRAMS FEED
		grams	*grams*	*grams*	*mgm*	*mgm*	*mgm.*	*mgm.*
131	1	73.0	66.5	5.43	19.4	8.2	27.9	150
132	1	46.0	43.0	3.72	8.7		19.6	
133	1	62.0	57.0	5.24	11.4	9.0	19.2	173
134	1	74.0	66.5	5.27	16.1	5.6	22.9	106
135	1	57.0	52.0	5.29	8.8	11.9	16.2	225
136a	1	82.0	75.0	5.16	16.1	14.6	20.5	283
137	1	45.0	41.5	3.67	7.5	6.0	17.4	165
138	1	67.0	59.5	5.32	12.8	11.3	20.3	213
139	1	54.5	46.5	4.23	11.0	9.7	21.7	229
Average							20.6	193
131	8	99.0	87.0	3.56	22.6	9.3	24.3	261
132	8	64.0	58.5	2.64	11.8	5.2	19.4	197
133	8	84.5	77.5	3.29	18.3	6.3	22.6	191
134	8	139.0	130.0	6.09	17.5	8.8	13.0	144
135	8	118.5	108.0	5.67	12.3	9.4	10.9	167
136b	8	154.0	140.0	4.39	20.3	12.1	13.8	276
137	8	88.5	77.5	2.66	16.7	5.3	(20.1)*	198
138	8	125.0	112.0	4.25	16.8	8.0	14.2	190
139	8	81.0	72.0	3.64	12.9	8.2	16.8	227
Average							16.9	206

* This value is not used here in computing the average, nor in future computations, because of the low food intake in proportion to the size of rat.

In the eighth experimental period, the rats were again put upon the nitrogen-free ration and collections of urine and feces were made daily after a three-day preliminary period, and composited for one week. In this period the loss of nitrogen in the urine per day per 100 grams of rat was, in all cases but one, less than the losses for corresponding rats in the first period, and sometimes very much less. It has been our experience that rats kept for several weeks confined in our metabolism dishes, show decreasing rates of endogenous loss of nitrogen. It seems probable that this indicates a diminished vitality of the experimental animals, just as a decreasing basal metabolism of energy has of late been found to be associated with decreasing vitality. Therefore, in the periods intervening between the two metabolism trials just described, it has been assumed that the endogenous losses of the rats decrease, in proportion to their weight, in a linear fashion from the value obtained in period 1 to the value obtained in period 8.

The fecal nitrogen excreted per 100 grams of food consumed in period 8 varied somewhat among the different rats from the corresponding values in period 1. In only two or three cases, however, is the difference so great that the average of the two values for any rat cannot be used in computing digestible nitrogen in the intervening periods. For these three cases, i.e., rats 131, 134, and 135, it was again assumed that the change from the value in period 1 to the value in period 8 was linear. The average value for the period was 206 mgm. of fecal nitrogen per 100 grams of food consumed.

RESULTS WITH LOW PROTEIN RATIONS

The rations containing the feeds to be tested were made up so as to contain 5 or 10 per cent of protein and to be adequate in all known respects except for the quality of the protein. In table 2 will be found the recipes for the rations and their nitrogen contents as determined by Kjeldahl analysis.

Rations 1, 2, and 3 contain the proteins of coconut meal, soy bean, and corn at a 5 per cent level. Such rations will support very little if any growth, and the experimental results obtained with them may logically be considered by themselves. These results are contained in table 3. A three-day preliminary period always followed a change of ration, and all collection periods were of seven days' duration.

The method of computing the utilization of the absorbed nitrogen may be illustrated by considering the data for rat 133, period 2. This rat consumed per day an average of 48.2 mgm. of nitrogen and excreted in the feces an average of 21.2 mgm. Of the latter loss, however, the body of the rat contributes some, estimated at 9.8 mgm. (column d) from the data from periods 1 and 8. Hence the daily feces contained 21.2 − 9.8 = 11.4 mgm. of food nitrogen. The amount of digestible nitrogen consumed per day was, therefore, 48.2 − 11.4 = 36.8 mgm. The daily excretion of urinary nitrogen was 22.0 mgm., but this also is partly derived from the body and partly represents a wastage of food nitrogen. The loss from the body, the endogenous nitrogen, is estimated from the urinary losses in periods 1 and 8 as being 11.7 mgm. Hence the food nitrogen wasted in the urine is 22.0 − 11.7 = 10.3 mgm. per day. Therefore, of the

TABLE 2

Percentage composition of experimental rations

CONSTITUENT	RATION*								
	1	2	3	4	5	6	7	8	9
Coconut meal	24.0			48.0			24.0		24.0
Rice bran								85.6	42.8
Soy bean		11.9			23.8	11.9			
Corn			60.5			60.5	57.8		
Starch	56.0	68.1	19.5	32.0	56.2	7.6			15.2
Agar	2.0	2.0	2.0	2.0	2.0	2.0			
Sucrose	5.0	5.0	5.0	5.0	5.0	5.0	5.2	1.4	5.0
Butterfat	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Salts	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Nitrogen content	0.897	0.919	0.957	1.704	1.743	1.782	1.768	1.694	1.687

*Osborne and Wakeman's preparation of Vitamin B was added to rations 1, 2, 3, 4 and 5 at the rate of 170 mgm. per 100 grams of ration.

TABLE 3

The utilization of the proteins of coconut meal, soy bean and corn fed at a level of 5 per cent

RAT NUMBER	PERIOD	INITIAL WEIGHT	FINAL WEIGHT	DAILY FEED CONSUMED	(a) DAILY INTAKE OF N	(b) DAILY URINARY N	(c) DAILY FECAL N	(d) METABOLIC N IN FECES	(e) ENDOGENOUS N	(f) ABSORBED N RETAINED	(g) UTILIZATION OF ABSORBED N
Coconut meal ration 1											
		grams	*grams*	*grams*	*mgm*	*mgm.*	*mgm.*	*mgm*	*mgm*	*mgm*	*per cent*
131	2	65.5	71.5	6.96	62.4	27.5	26.2	11.6	18.6	38.9	81
132	2	42.5	45.0	4.06	36.4	16.7	15.2	8.0	8.5	21.0	72
133	2	58.5	60.0	5.37	48.2	22.0	21.2	9.8	11.7	26.5	72
131	3	71.5	69.0	5.19	46.6	24.1	19.7	9.4	18.8	31.0	85
132	3	45.0	48.0	4.09	36.7	16.4	13.5	8.1	9.0	23.9	76
133	3	60.0	62.0	5.13	46.0	21.6	17.7	9.3	12.3	28.3	75
Average											77
Soy bean ration 2											
134	2	69.0	81.0	8.13	74.7	30.0	14.7	9.0	16.1	55.1	80
135	2	52.5	60.5	5.81	53.4	21.6	11.8	12.6	8.7	40.5	76
136a	2	76.0	72.0	4.60	42.3	27.8	16.8	13.0	15.2	25.8	(67)*
134	3	81.0	75.5	4.78	43.9	26.0	11.8	5.5	15.7	27.3	(73)*
135	3	60.5	56.0	3.54	32.5	23.5	9.8	7.4	8.6	15.2	(50)*
136a	3	72.0	71.5	3.97	36.5	32.2	14.1	11.2	14.7	16.1	(48)*
Average											78
Corn ration 3											
137	2	47.5	45.0	3.97	38.0	18.6	13.5	7.2	8.1	21.2	67
138	2	63.0	71.5	6.55	62.7	28.3	16.5	12.8	13.0	43.7	74
139	2	50.5	51.5	5.19	49.7	22.3	16.2	11.8	10.7	33.7	74
137	3	45.0	49.5	4.33	41.4	21.1	11.0	7.8	8.2	25.3	66
138	3	71.5	77.5	6.77	64.7	27.8	18.5	13.6	13.9	45.9	77
139	3	51.5	54.0	5.17	49.5	23.0	14.7	11.8	10.7	34.3	74
Average											72

* These values are not included in the average because the food intake of these periods was obviously inadequate to cover the energy requirements.

36.8 mgm. of coconut nitrogen absorbed, only 36.8 − 10.3 = 26.5 mgm., or 81 per cent, is retained for maintenance and growth. This percentage is taken as a measure of the biological value of coconut protein at this level of intake for this particular rat and period. It is to be noted especially that the values in column f are not equal to the nitrogen balance as ordinarily computed.

The experimental data for coconut meal and for corn are satisfactory, since the rations were in general consumed in sufficient amounts to maintain weight. The average utilization of the coconut meal protein was 77 per cent and of corn 72 per cent. The individual values, however, were not sufficiently consistent to warrant the conclusion that the proteins of the coconut are of higher biological value than the proteins of corn.

The results with the soy bean ration were unsatisfactory except for two periods, i.e., period 2 for rats 134 and 135. In all other periods the food intake was obviously insufficient and low utilization of the nitrogen could not be attributed only to the chemical characteristics of the protein. The percentages obtained for the two exceptional periods were 80 and 76, averaging 78.

There are no grounds for believing, therefore, that these three types of food protein have distinctly different values in nutrition aside from differences in digestibility, when fed at this low level.

RESULTS WITH MEDIUM PROTEIN RATIONS

In most of our metabolism experiments on rats we have been able to get more concordant results and hence more satisfactory results with rations containing approximately 10 per cent of protein than with our 5 per cent rations, mainly because such rations are consumed in larger quantities and keep the rats in better condition. This level of protein intake is, however, not high enough to support maximum growth, at least when the protein is of vegetable origin, so that the results of the nitrogen balance studies will not be vitiated by the consumption of protein in amounts above the body's requirements, and by the utilization of protein primarily for energy production.

In table 4 are included the results of balance studies on the proteins of coconut meal, soy beans, and corn fed in rations containing approximately 10 per cent of protein. With the excep-

TABLE 4

The utilization of the proteins of coconut meal, soy bean, and rice bran fed at a level of 10 per cent

RAT NUMBER	PERIOD	INITIAL WEIGHT	FINAL WEIGHT	DAILY FEED CONSUMED	(a) DAILY INTAKE OF N	(b) DAILY URINARY N	(c) DAILY FECAL N	(d) METABOLIC N IN FECES	(e) ENDOGENOUS N	(f) ABSORBED N RETAINED	(g) UTILIZATION OF ABSORBED N
					Coconut meal ration 4						
		gram	*gram*	*grams*	*mgm*	*mgm*	*mgm*	*mgm*	*mgm*	*mgm*	*per cent*
131	4	71.5	78.0	6.36	108.1	50.3	12.0	12.6	19.7	48.4	61
132	4	59.5	50.0	4.74	80.8	37.1	33.9	9.3	9.7	28.5	51
133	4	64.0	70.0	5.79	98.7	43.1	38.3	10.5	13.9	41.7	59
131	5	78.0	83.0	7.31	124.6	55.0	51.1	15.6	20.4	54.5	61
132	5	50.0	55.0	4.71	80.8	35.0	32.0	9.3	10.2	33.3	57
133	5	70.0	72.5	5.95	101.4	44.9	39.6	10.8	14.7	42.4	58
Average											58
					Soy bean ration 5						
134	4	80.5	95.5	7.59	132.3	56.2	22.5	9.2	16.4	79.2	67
135	4	60.5	69.5	5.71	100.0	44.8	18.2	11.5	9.0	57.5	62
136a	4	72.0	69.0	3.49	60.8	46.8	19.5	9.9	14.5	18.9	(37)
134	5	95.5	109.0	8.07	140.6	62.8	21.3	10.1	17.6	84.2	65
135	5	69.5	83.0	7.20	125.5	54.0	22.5	13.9	10.0	72.9	62
136a	5										
Average											64
					Rice bran ration 8						
134	6	112.5	130.0	11.81	200.6	66.5	81.8	16.1	19.2	87.6	65
135	6	91.5	105.0	11.18	189.4	61.5	80.6	20.7	12.1	80.1	62
136b	6	137.5	150.0	12.57	212.9	71.7	98.4	34.6	19.9	90.3	65
134	7	130.0	146.5	12.50	211.7	59.1	93.5	17.0	19.9	95.9	71
135	7	105.0	126.0	13.02	220.6	59.1	94.7	23.0	13.4	103.2	70
136b	7	150.0	166.0	13.34	226.0	65.6	108.7	36.8	21.8	110.3	72
Average											67

tion of the one period for rat 136a on the soy bean ration, the results of all periods were satisfactory. For coconut meal, the results for the six balance periods were remarkably concordant,

TABLE 5

The utilization of the proteins of corn, coconut meal, soy bean and rice bran fed in various combinations at a level of 10 per cent

RAT NUMBER	PERIOD	INITIAL WEIGHT	FINAL WEIGHT	DAILY FEED CONSUMED	(a) DAILY INTAKE OF N	(b) DAILY URINARY N	(c) DAILY FECAL N	(d) METABOLIC N IN FECES	(e) ENDOGENOUS N	(f) ABSORBED N RETAINED	(g) UTILIZATION OF ABSORBED N
Corn plus soy bean ration 6											
		grams	*grams*	*grams*	*mgm*	*mgm.*	*mgm*	*mgm*	*mgm*	*mgm*	*per cent*
137	4	53.0	65.0	6.29	112.1	45.2	16.3	11.4	10.3	72.3	67
138	4	82.0	93.5	7.81	139.2	59.7	29.4	15.7	15.5	81.3	65
139	4	59.0	64.5	5.75	102.5	44.7	24.7	13.1	12.1	58.3	61
137	5	65.0	74.0	7.31	130.3	50.7	30.0	13.2	12.1	74.9	66
138	5	93.5	101.0	6.95	123.8	51.8	29.4	14.0	16.3	72.9	67
139	5	64.5	70.0	5.67	101.0	43.6	25.8	12.9	12.7	57.2	65
Average .											66
Coconut meal plus corn ration 7											
131	6	85.0	104.0	9.55	168.8	82.8	47.7	22.0	24.0	84.3	59
132	6	60.0	66.0	5.94	105.0	52.4	31.2	11.7	12.3	45.4	53
133	6	75.5	87.0	7.67	135.6	65.2	36.8	14.0	18.0	65.6	58
131	7	104.0	108.0	8.30	146.7	73.7	46.2	20.4	26.3	73.5	61
132	7	66.0	71.5	6.11	108.0	51.5	34.3	12.0	13.4	47.6	56
133	7	87.0	95.0	7.32	129.4	59.8	41.0	13.3	20.2	62.1	61
Average......										. .	58
Rice bran plus coconut meal ration 9											
137	6	72.5	90.0	8.94	150.8	51.5	61.6	16.2	14.1	68.0	65
138	6	101.5	115.0	9.35	157.7	62.1	60.0	18.8	17.3	71.7	62
139	6	73.0	80.0	8.26	139.3	49.9	71.0	18.8	13.9	51.1	59
137	7	90.0	96.0	9.02	152.2	46.8	75.7	16.3	16.2	62.2	67
138	7	115.0	130.0	11.41	192.5	66.9	84.9	22.9	18.4	82.0	63
139	7	80.0	89.0	8.99	151.7	54.1	73.8	20.5	14.8	59.1	60
Average	....	.	.	.	...	. .....	.	.	.	....	63

the average utilization coefficient being 58. For the four soybean periods, the results agreed fairly well, averaging 64, all percentages being above 60. For the rice bran ration, the first three periods (6) agreed well among themselves, but the next three periods (7) were all distinctly higher than the first three. The average for all six periods was 67 per cent.

From these results it would seem that the proteins of coconut meal are slightly but distinctly less efficient than the proteins of soy beans for structural purposes in the body of the rat. A distinct difference between soy bean proteins and rice bran proteins is not so clear, though our results do favor the latter.

In table 5 are given data obtained on rations containing proteins from two sources, approximately half of the protein coming from each of the constituent foods. The total protein content of these rations closely approximated 10 per cent. In other tests in this laboratory we have shown that corn protein alone, fed at this level, has a biological value somewhere between 50 and 60, in most tests approximating to 60. In table 5 it will be seen that a mixture of proteins from coconut meal and corn has a value of 58 on the average, so that no supplementary effect of the proteins of these two feeds appears to exist. Soy bean and corn proteins have an average value of 66. This may indicate a slight supplementing effect of one source of protein on the other, though the data are too few to permit a definite statement to this effect. Rice bran and coconut meal proteins, mixed in equal proportions, have an average value of 63, exactly midway between the average values of the unmixed proteins, i.e., 58 for coconut meal and 67 for rice bran. In this case, therefore, there is no reason to suspect any supplementary effect, that is, an improvement in the quality of the proteins of one feed by mixture with the proteins of another feed.

These tests on mixed rations are in line with the general experience of this and other laboratories, that vegetable proteins do not exhibit striking supplementary effects on one another. It is only when animal proteins are mixed with vegetable proteins that such effects are to be expected.

THE NET PROTEIN VALUES OF FEEDS

By the combined use of average percentages of total protein in feeds, average digestion coefficients, measuring the wastage of protein in digestion, and average biological values, measuring the wastage of protein in metabolism, it is possible to compute what might well be termed the "net protein" content of feeds. Such computations are illustrated by the values given in table 6. The percentages of digestible protein are taken from Henry and Morrison's tables for ruminants, and the biological values of the proteins are taken from this investigation and that of Nevens previously referred to, with the exception of the value for corn which is the average of a large number of trials with rations containing approximately 10 per cent of protein.

TABLE 6

FEED	CONTENT OF DIGESTIBLE PROTEIN	BIOLOGICAL VALUE OF DIGESTIBLE PROTEIN	CONTENT OF NET PROTEIN
	per cent	*per cent*	*per cent*
Corn	7.5	58	4.3
Rice bran	7.9	67	5.3
Soy beans	30.7	64	19.6
Coconut meal	18.8	59	11.1
Cottonseed meal	37.0	66	24.4
Alfalfa hay	10.6	62	6.6

The use of net protein values may be illustrated as follows: A 1000 pound cow requires for maintenance, say 0.5 pound of protein per day. She produces daily 30 pounds of milk containing 3 per cent of protein, or 0.9 pound of milk protein. Her daily protein requirement therefore is 1.4 pound. Now alfalfa hay contains 6.6 pounds of net protein per 100 pounds. Therefore, $(1.4 \div 6.6) \times 100 = 21.2$ pound of alfalfa hay daily would be required to keep her in nitrogen equilibrium. If enough of a grain mixture containing 3 parts corn, 1 part rice bran, and 1 part cottonseed meal, is to be fed to cover the protein requirements of milk production, the calculation would be:

$$0.9 \div \{(3 \times 4.3 + 5.3 + 24.4) \div 5\} \times 100 = 10.6 \text{ pounds}$$

Such calculations assume, of course, that no considerable supplementing effect of the proteins of one feed upon those of another occurs, and that the biological values of digestible protein obtained with rats have a wide applicability to other species of animals and to other physiological functions than growth and maintenance. The first assumption is probably perfectly justified. Whatever slight supplementary effect may occur would enhance the value of the protein and hence the calculation would give results slightly higher than the actual requirement. The estimated allowance of feed would therefore always be a safe one if this were the only possible error involved.

The second assumption is, of course, open to considerable question. As far as differences between species are concerned we have recalculated some nitrogen balance results published at Wisconsin on pigs and have obtained biological values for corn ranging from 48 to 60, quite analogous to those we have obtained with rats, and biological values for the mixed proteins of milk of 80 to 85, again checking closely our values with rats. We know of no data on other species sufficiently complete to permit of comparison with our data on rats. That the value of a food protein in the elaboration of the proteins of milk may be significantly different from its value in maintenance and growth seems probable, though until information on the former point is available, a calculation such as that given above may be considered a good first approximation to the truth. More confidence, of course, can be felt in such computations applied to maintenance and growth requirements, than to milk requirements.

For example, according to Armsby a dairy calf one year old and weighing 400 pounds requires daily 0.24 pound of digestible protein for maintenance and when gaining at a maximum rate puts on 0.14 pound of protein daily. The former figure is probably somewhat high as a measure of the break-down of body tissues per day. It is certainly a safe estimate of the need for protein for maintenance. Taking it in this sense, we may say that the total protein requirement of the calf is 0.38 pound per day. If the calf is raised on alfalfa hay, it will require per day $0.38 \div 0.66 = 5.76$ pounds to provide the required amount of protein. Since a calf of that size and age will require some 15 pounds of alfalfa hay to cover its energy requirements, according to Armsby's growth standard, the consumption of this much hay will evidently provide ample protein for growth. In fact, half the hay could be replaced by an amount of corn equivalent to it in net energy (i.e., 3 pounds) without fear of restricting growth by an insufficient supply of protein.

EFFECT OF AUTOCLAVING ON VITAMIN CONTENT IN MILK

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Whether or not the vitamin of milk are destroyed by pasteurization or sterilization has been the subject of much debate during recent years. Inasmuch as milk is a perfect food, containing all the nutriments required by a growing body in proper proportion and in palatable and digestible form, its vitamin content deserves special consideration.

Feeding experiments were carried on to determine how the fat-soluble A vitamin and the water-soluble B are affected by heating. The C vitamin, or the antiscorbutic vitamin, is not necessary for the growth of the animals (mice) used in the experiments as this vitamin is synthesized by them.

Milk was autoclaved at ten pounds pressure for fifteen minutes and fed to growing mice which had been fed for a period of about fifteen days on a diet devoid of vitamins, but complete in respect to protein, carbohydrates, fats and minerals.

Suzuki and his coworkers in their feeding experiments found that mice fed on a vitamin free diet died in ten to fifteen days.[1] In Sherman and Smith's book "The Vitamins," Drummond states, "The length of time that an animal is able to maintain itself on a diet deficient in B without suffering serious loss of body weight appeared to be directly proportional to the age, at which the restriction is imposed" (p. 44).

In case of the A vitamin the animal may cease to grow, or continue slowly or may continue for a longer or shorter period depending upon the store of vitamin A in the body of the animal at the beginning of the experiment and the food consumption of the animal.[2]

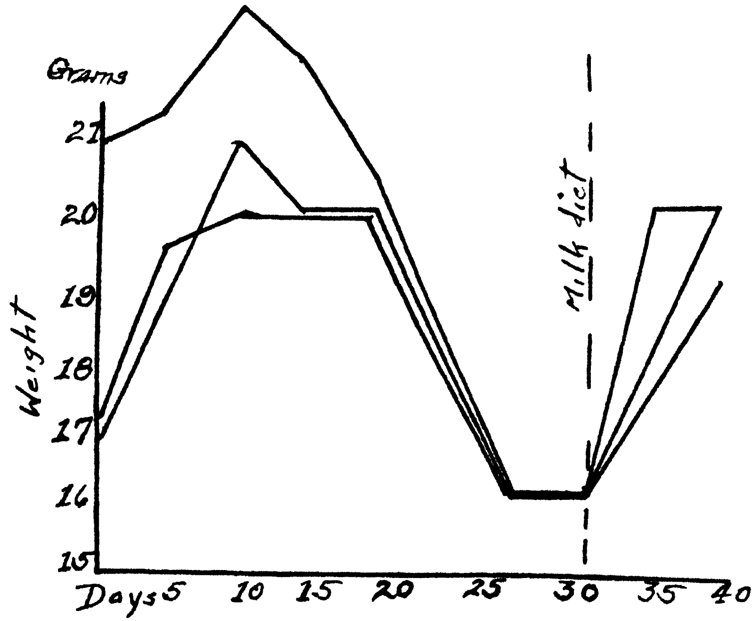
---

[1] **Sherman and Smith, "The Vitamins," p. 27.**

[2] **However, the age of the animal is also worthy of consideration.**

The results on graph 1 show that on the addition of milk two 17 gram animals put on 4 grams each in a five-day period. Evidently the heating of milk at 10 pounds pressure for fifteen minutes does not destroy to any appreciable extent the B vitamin content. A vitamin was supplied in the basal diet.

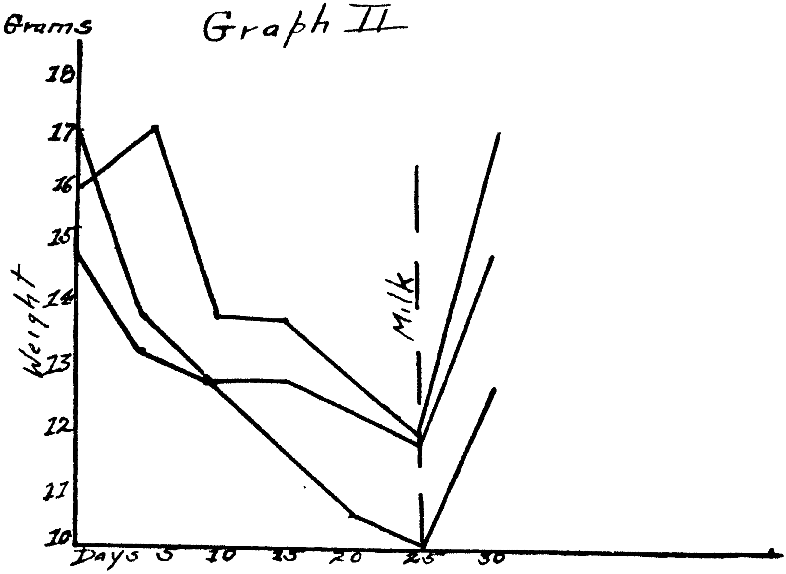
Graph I

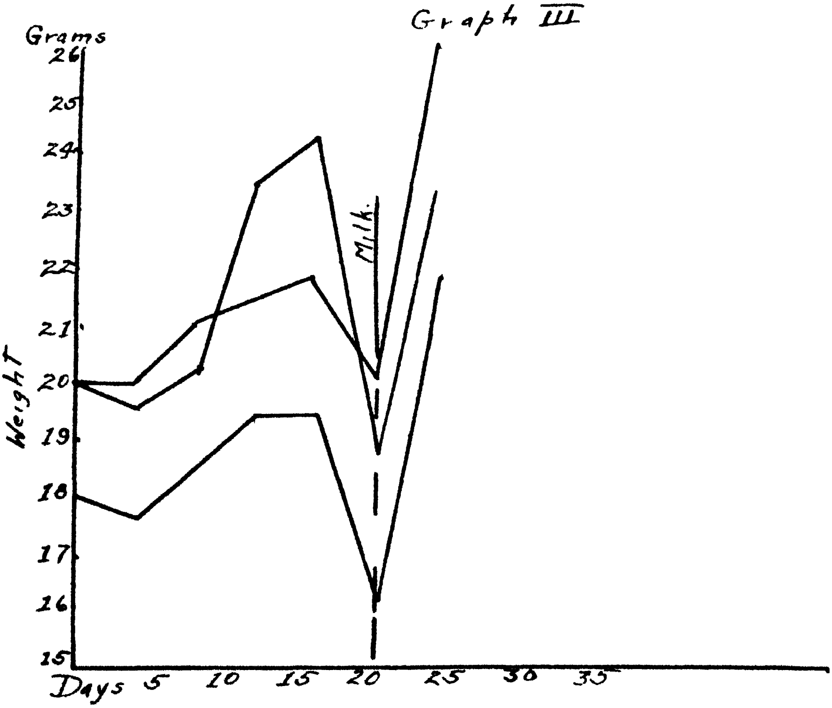


Basal diet (lacking in B vitamin)

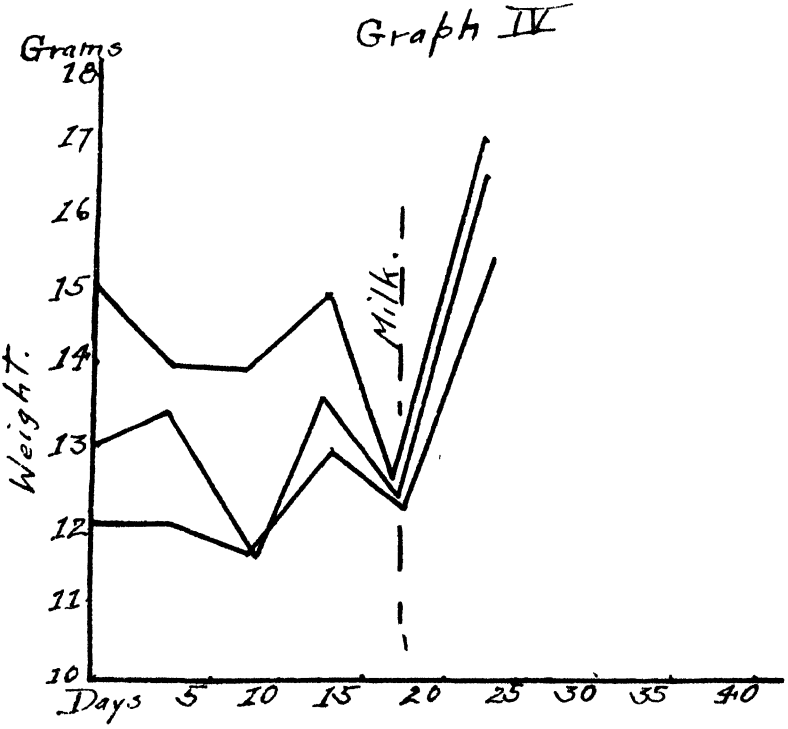
	per cent
Casein	18.
Salt no. 35	3.7
Dextrin	71.3
Butterfat	5.0
Agar	2.0

Another experiment was conducted using milk heated at 15 pounds pressure for fifteen minutes. Here again the graph 2 shows remarkable growth upon the administration of milk after a decline in weight for a period of twenty-five days on a basal diet as described above.


Graph II
Grams
Weight
18
17
16
15
14
13
12
11
10
Milk
Days 5 10 15 20 25 30


Graph III
Grams
Weight
26
25
24
23
22
21
20
19
18
17
16
15
Milk.
Days 5 10 15 20 25 30 35

Bacillus subtilis (hay bacillus), its source and habitat being hay, straw, soil, dust, milk, etc., was fed to mice in the diet described above to determine its toxicity. At ten days the coats of the animals were shabby, but they slowly gained weight up to twenty days and then dropped. Upon the addition of autoclaved milk at 15 pounds pressure for fifteen minutes, a sudden gain occurred. The animals gained from 20, 18.5, and 16 grams, to 26, 23.5, and 22 grams respectively in a five-day period (graph 3).

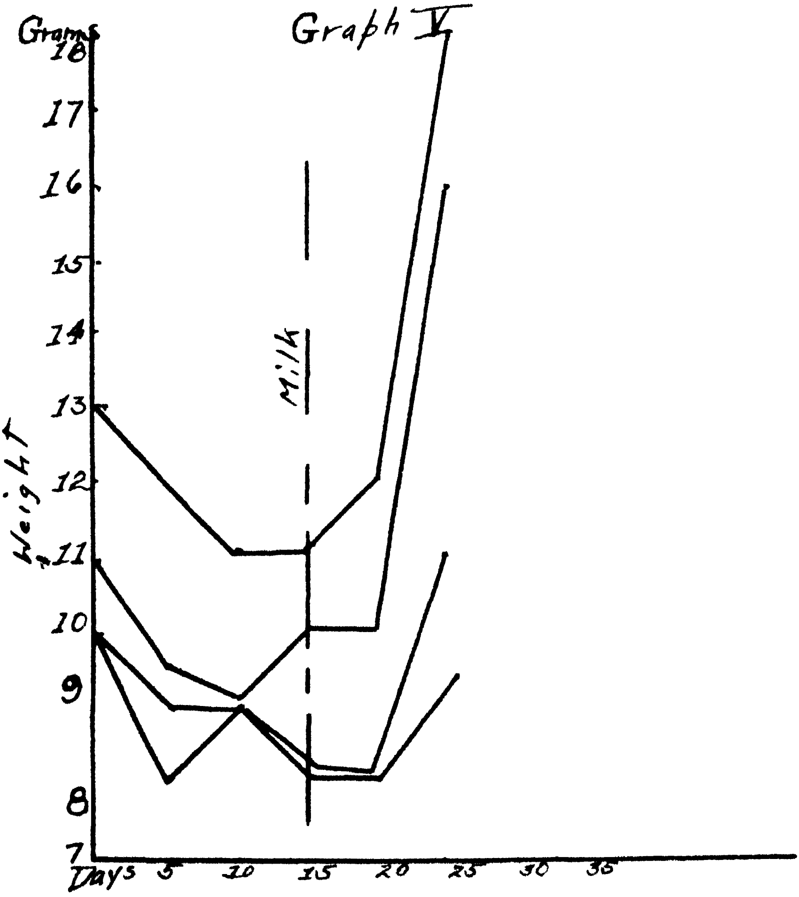


In another experiment the following basal diet was fed to mice.

	per cent
Rolled oats (treated to remove any traces of vitamin A)	40.0
Casein (also treated to remove A)	5.0
Salt mixture no. 35	2.5
Lard	5.0
Dextrin	47.5

This diet lacks in A vitamin.

The animals begain to show signs of xerophthalmia (eye disease) at about sixteen days and loss of weight. However upon the addition of autoclaved milk three to five grams were gained by each animal in a five-day period (graph 4).



An abundant growing soil organism was fed to younger mice in a basal diet lacking in B vitamin. Here the toxic properties of the organisms were marked, since it took five days to recover when autoclaved milk was added and this was followed by a gain in weight (graph 5).

CONCLUSIONS

The fat-soluble A and water-soluble B of milk autoclaved at 10 pounds pressure, and 15 pounds pressure for 15 minutes are not affected to any appreciable extent when fed as a source of vitamin.

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THE OPTIMUM QUANTITY OF SKIMMILK FOR CALF FEEDING

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Received for publication November 27, 1922

The experiment on calf feeding reported below was conducted at the Dairy Division Experiment Farm, Beltsville, Maryland, and had for its object, first to find out the quantity of skimmilk which would give the best results as regards gains in weight and economy of gains; second to find out if feeding large quantities would cause scours.

There were four calves in each group, balanced as nearly as possible with reference to breed and body weight at birth. One group was given a daily ration, at the rate of $\frac{1}{7}$ of the body weight, the quantity being regulated by body weights taken every ten days. Two other groups were fed at the rate of $\frac{1}{6}$ and $\frac{1}{5}$ of their body weights and the fourth group was given all the milk the calves would drink, twice a day. Each calf received its mother's milk until it was ten days old. The change to skimmilk was then made gradually and at the age of fifteen days the calf was on an entire skimmilk ration. The experiment ran for seventy days. The average of the weights for three consecutive days at the end of the seventy days was taken as the final weight. The results are given in tabular form on following page.

The gains increased with the quantity of milk fed, the calves receiving all they would drink, making at least 50 per cent larger gains than those receiving milk at the rate of $\frac{1}{7}$ of their body weight. To do this they drank about 80 per cent more skimmilk. As a result the milk required per one pound of gain was greater with the heavily fed calves, although it will be observed that the results are not entirely consistent in this respect. Apparently the calves which received all the milk they would drink made gains more economically than those fed at the rate of $\frac{1}{5}$ of the body weight.

Satisfactory gains were made by feeding skimmilk at the rate of $\frac{1}{7}$ of the body weight. Whether or not more than this is to be

Gains in weight made by calves on various quantities of skimmilk

CALF NUMBER	BREED	BIRTH WEIGHT	FINAL WEIGHT	DAYS ON EXPERIMENT	TOTAL GAIN	DAILY GAIN	TOTAL MILK CONSUMED	MILK PER DAY	MILK PER POUND GAIN
Fed at the rate of ⅐ of body weight									
		pounds	*pounds*		*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
59	Gr. Hol.	64	130 0	70	66 0	0 94	902 0	12.89	13.7
213	P. B. Hol.	98	182 0	70	84.0	1.20	1266.0	18.09	15.1
67	Gr. Hol.	56	129.5	70	73 5	1 05	859.5	12.28	11.7
70	Gr. Guer.	63	107.0	70	44.0	0.63	757.7	10.82	17.2
Average..........		70 2	137 1		66 9	0 95	946 3	13 52	14.2
Fed at the rate of ⅙ of body weight									
57	Gr. Guer	68	141.0	70	73.0	1.04	1142.0	16 31	15.6
60	Gr. Guer.	62	138 0	70	76.0	1 09	1046 0	14.94	13.8
64	Gr. Hol.	85	164 0	70	79.0	1.13	1305.0	18 64	16.5
215	P. B. Hol.	85	161 0	70	76 0	1.09	1264.9	18 07	16.6
Average..........		75 0	151 0		76.0	1.09	1189.5	16.99	15.7
Fed at the rate of ⅕ of body weight									
58	Gr. Guer.	58	149.0	70	91.0	1.30	1279.0	18 27	14.1
118	P. B. Guer.	77	147.0	70	70.0	1.00	1472.0	21.03	21.0
63	Gr. Hol.	70	185.0	70	115.0	1.64	1659.5	23.71	14.4
214	P. B. Hol.	83	161.0	70	78 0	1 11	1457 2	20.82	18.7
Average..........		72.0	160.5		88.5	1.26	1466 9	20.96	16.6
Fed all they would consume twice daily									
18	Gr. Hol.	89	221.0	70	132.0	1.89	1973.0	29.19	14.9
106	P. B. Guer.	84	200.0	70	116 0	1 66	1898 0	27.11	16.4
110	P. B. Guer.	68	163.0	70	95.0	1.36	1539.0	21.99	16.2
68	Gr. Guer.	57	129.0	70	72.0	1.03	1372 0	19.60	19.1
Average..........		74.5	178.2		103.7	1.48	1695.5	24.22	16.3

given will depend upon the rate of growth desired and upon the quantity of skimmilk available. Rather than throw away the skimmilk it would be better to feed it to the calves even if the larger quantities are not utilized so economically.

No bad results from heavy feeding were noticed, although all of the calves in group four, except no. 68, drank at times more than 40 pounds of skimmilk a day. This would indicate that overfeeding in itself is not a common cause of scours.

AN EXPERIMENT MANGER

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One of the difficulties in conducting feeding or digestion trials with cows is in having a suitable manger. For these purposes the manger should prevent wastage of feed due to the cows throwing it over the top of the manger in front of them or drawing it towards them among the bedding. In addition, cows should be prevented from stealing feed from each other.

A manger which has been in use in the Dairy Husbandry Section of the Iowa Agricultural Experiment Station for the last four years has been found very satisfactory. Sections of it are shown in figure 1.

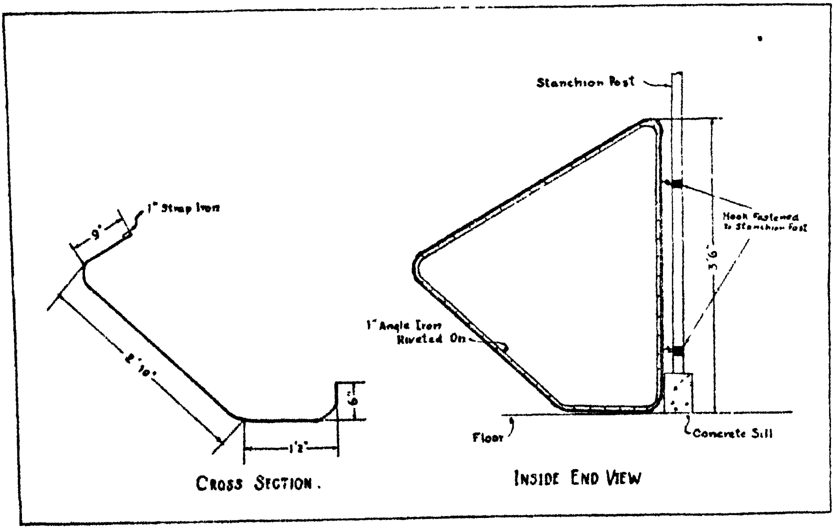

Fig. 1 Details of an Experiment Manger

It is constructed of galvanized iron with one-inch angle iron for joining the ends to the main body and the flange turned up in front is supported with 1-inch strap iron. On the stanchion post at each end of the manger there are two hooks. Each hook and its attachment consists of two pieces of 2-inch strap iron which are bolted around the stanchion post and the end of one of the pieces in each pair is extended and formed into a hook. Eyes to correspond are on the manger ends. The inner edge is level with the top of the 6-inch concrete sill in which the stanchion posts are set, and the concrete sill aids in the prevention of feed being wasted among the bedding.

All corners in the mangers except where angle iron is used are rounded and this tends to keep the mangers clean. From the base of the sill to the front of the manger at the base is 14 inches. From there the front slopes upward at an angle of 45 degrees and then curves round more rapidly and the top of the manger extends inwards for 9 inches.

The length of the mangers in use is 40 inches but they can be made of any length to suit the distance between the stanchion posts.

BOOK REVIEW

The Technical Control of Dairy Products by Timothy Mojonnier and Hugh Charles Troy is a real attempt to assemble an extensive treatise on the testing, analyzing and standardizing of dairy products and the manufacture of ice cream, condensed and evaporated milks. Beginning with a description of the dairy plant laboratory and its equipment a detailed technical discussion of the average composition of milk and the nature of milk constituents is presented in the form of an introduction into the field of dairy manufacturing.

In subsequent six chapters are given precise directions and pointed precautions in regards to sampling and testing various dairy products for butterfat and total solids. A brief history of the various tests for butterfat is related and emphasis is made regarding the Mojonnier butterfat test or the modified Rose-Gottlieb method as employed in connection with the Mojonnier Tester.

Several methods of standardizing milk, cream and condensed milks for butterfat and solids not fat plus detailed calculations for condensed milks are illustrated by formulas of typical problems and by the aid of extensive tables.

A special chapter is devoted to the composition and standardization of ice cream mixes and is supplemented by a set of problems and painstaking compiled tables to facilitate computations involved in the standardization of the ice cream batch.

Under Chapter XV entitled "The Overrun in Ice Cream" various factors influencing the same through the different processes employed in ice cream manufacturing are discussed in the light of facts learned in different experiments on ice cream making.

A very instructive chapter on dairy bacteriology with explanations of "starters" and their uses in dairy products offers material which has never before been brought in such compact and practical shape. A chapter on dairy chemistry covering the most practical chemical analyses of constituents employed in dairy manufacturing is very comprehensive and can be highly recommended as a reliable reference to students in dairying.

Detailed description of the vacuum pan and a simple and clear presentation of the manifold problems involved in the processes of condensing milk and methods of sterilizing evaporated milk is a prominent feature of this treatise.

Essentials pertaining to milk inspection and scoring of various dairy products followed by definitions and standards for dairy and related products are conspicuously displayed.

The last Chapter XXII gives diagrammatic illustrations of flow sheets of various phases of dairy manufacturing; indicates temperatures for holding, processing, and storing dairy products; it also gives a discussion relating the properties of metals and alloys and their effects on milk.

There are useful tables in the appendix and at the end of each chapter a bibliography of references is given to indicate the source of information on the various problems discussed in each chapter of the book. The systematic arrangement of the tables and illustrations in connection with a clear expression of rather technical matter makes it easily comprehended by the nontechnical reader as well as the dairy expert. This book provides valuable information to the dairy technologist, the ice cream maker, the manufacturer of condensed and evaporated milks as well as to the creamery man and student in dairy manufacturing. It may be considered a worth while attempt to furnish the dairy manufacturer with a reference book somewhat similar in nature to Henry's "Feeds and Feeding" used by the stockman, the production man.

BENJAMIN MASUROVSKY,
Lincoln, Nebraska.

FRITZ WILHELM WOLL

Dr. Fritz Wilhelm Woll, Professor of Animal Nutrition, University of California, well known as a writer on animal feeding and dairy subjects, died at Berkeley, Calif., December 6, 1922.

Dr. Woll received his early education in Christiania, Norway, obtaining the degree of Bachelor of Philosophy from the Royal Fredericks University, Christiania, in 1883. Degrees of Master of Science and Doctor of Philosophy were conferred by the University of Wisconsin in 1886 and 1904, respectively. In 1887, Dr. Woll was appointed second Assistant Chemist, Wisconsin Agricultural Experiment Station, rising to Chemist for the Station in 1897. He became Professor of Agricultural Chemistry, University of Wisconsin in 1906, which position he held until 1913, when he was called to the University of California as Professor of Animal Nutrition, holding that chair until his death.

Dr. Woll was the author of many works, which have been reissued in a number of editions, among these may be mentioned the following:

A Book on Silage, revised edition, 1900;

A Translation of Modern Dairy Practice (From Swedish of G. Grotenfelt) 1894; 3rd edition, 1905;

A Handbook for Farmers and Dairymen, 1897; 6th edition, 1914;

Testing Milk and Its Products (with Professor E. H. Farrington) 1897; 24th edition, 1918;

Productive Feeding of Farm Animals, 1915; 2nd edition, 1916; 3rd edition, 1921, and

Feed Manual and Note Book, 1917.

While at the Universities of California and Wisconsin Dr. Woll accomplished a large amount of scientific work. This is shown by the series of important and timely bulletins of the respective agricultural experiment stations. He was also an extensive contributor to technical publications and agricultural and dairy papers. His articles were always replete with valuable aid to dairymen and feeders in general.

It is owing, primarily, to the untiring efforts of Dr. Woll that cow-testing associations, which proved of so much value and importance to the dairy industry of California, were developed and placed on a business-like and permanent basis.

Dr. Woll was a member of many agricultural and scientific societies, including Wisconsin Academy of Sciences, Arts and Letters; Society for the Promotion of Agricultural Science; American Society for Animal Production; Association of Official Agricultural Chemists (president, 1909-11); American Dairy Science Association; Sigma Xi, International Jury Panama Pacific International Exposition, 1915.

The passing of Dr. Woll is a great loss to the University of California and to the animal industry of the whole country.

M. E. JAFFA.

THE EFFECTS OF UNDERFEEDING ON MILK SECRETION

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Received for publication, February 12, 1923

It has been shown by Eckles and Palmer (1) that underfeeding has a marked influence on the composition of milk. They recognize three types of underfeeding: (*a*) the withdrawal of a certain portion of the total food of the animal, (*b*) the reduction to a normal plane of animals on a supernormal plane of nutrition, and (*c*) the physiological underfeeding resulting from the strong stimulus for milk secretion during a number of days after parturition when it is not possible for the appetite of the cow to supply the demands for nutrients to support both the milk flow and her body weight.

It was found in all of their experiments that a high fat test accompanied the reduction in the plane of nutrition; and the effect was greatest in the cases of greatest reduction. The increase in the percentage of fat was especially marked when the cow had been on the supernormal plane of nutrition for a considerable period before the reduction of the plane. The influence of physiological underfeeding (2) has been recognized in making large short time official records during which time an abnormally high test results.

The object of this paper is to present data showing the effect of the first two types of underfeeding especially as they affect the reliability of the two-day semi-official yearly record.

Three cows, a Jersey, a Holstein-Freisian, and an Ayrshire, in the first half of their lactation period were selected for the first experiment. Before being placed on experiment, it was found that the cows were on a supernormal plane of nutrition as determined by weighing all hay, grain and silage during a three-day preliminary period.

Following the preliminary period, the cows were put on a ration calculated to furnish as nearly as possible exact requirements as determined by the feeding standards, They received a ration composed of alfalfa hay, silage, and a grain mixture. This ration was continued for ten days. One half of each constituent in the ration was then removed and the reduced ration continued for ten days. The original amount of feed was then again gradually given.

The results are shown in table 1 and chart 1. It will be seen that there is a very decided increase in the per cent of fat in the milk when the ration was reduced one-half. The maximum per cent of fat occurred during either the second or third day after the reduction in feed was made. While there was some variation in the tests after reaching the high point, they remained considerably above normal during the remainder of the period. As soon as the cows were put back on full feed, the per cent of fat in each case went down very rapidly and decidedly and remained considerably below normal during the following ten day period.

The quantity of milk produced was decidedly affected in the opposite way. The greatest reduction in milk occurred the second day after the reduction in the feed, followed by a gradual decline throughout the period. When the cows were brought back to full feed they gradually increased in production but did not reach that of the three day preliminary period during the following ten days.

The increase in the per cent of fat was not sufficient to cause an increase in the total amount of fat due to the reduction of milk.

The weight of the cows in the group was reduced considerably during the reduction in the feed, averaging 78 pounds per cow.

It is commonly thought that a feverish condition of a cow may be a cause of the increase in the per cent of fat in the milk. To determine whether underfeeding would cause a feverish condition, the temperatures of the animals were taken at each milking. The figure recorded is the average of these readings. It will be noted that feed reduction did not produce a feverish

TABLE 1

The effect of feed reduction on milk secretion

DATE	AVERAGE MILK PER DAY	TRUE AVERAGE FAT	AVERAGE FAT PER DAY	BODY TEMPERATURE	AVERAGE WEIGHT OF COWS
1920	*pounds*	*per cent*	*pounds*		*pounds*
February 19	38.7	4.051	1.569	101.03	
February 20	40.3	3.869	1.561	101.22	
February 21	39.7	4.259	1.692	101.00	
Average	39.6	4.059	1.607		884
February 22	40.3	3.862	1.558	101.03	
February 23	37.8	4.070	1.539	100.77	
February 24	36.7	4.280	1.572	100.77	
February 25	37.5	4.052	1.521	100.86	
February 26	36.5	3.916	1.430	100.78	
February 27	36.8	4.062	1.495	100.97	
February 28	35.8	3.918	1.402	100.57	
February 29	34.4	4.304	1.481	100.77	
March 1	36.5	3.615	1.318	101.02	
March 2	34.2	3.777	1.293	100.62	
Average	36.7	3.985	1.461		891
March 3	36.8	3.772	1.387	101.09	
March 4	28.6	4.500	1.289	100.27	
March 5	28.1	4.849	1.363	100.46	
March 6	27.3	4.494	1.227	100.11	
March 7	25.8	4.366	1.127	100.66	
March 8	25.0	4.531	1.131	100.99	
March 9	24.8	4.591	1.140	101.66	
March 10	25.7	4.440	1.141	102.03	
March 11	25.5	4.687	1.194	100.62	
March 12	26.4	4.560	1.120		
Average	27.2	4.453	1.212		813
March 13	23.6	4.363	1.031	101.20	
March 14	28.1	3.801	1.067	100.89	
March 15	28.9	3.717	1.073	101.27	
March 16	31.4	3.673	1.153	100.84	
March 17	33.8	3.710	1.254	101.01	
March 18	32.8	3.625	1.189	101.12	
March 19	33.2	3.624	1.203	101.02	
March 20	34.1	3.582	1.222	100.89	
March 21	35.2	3.563	1.254	100.82	
March 22	34.3	3.823	1.313	101.04	
Average	31.5	3.728	1.176		900

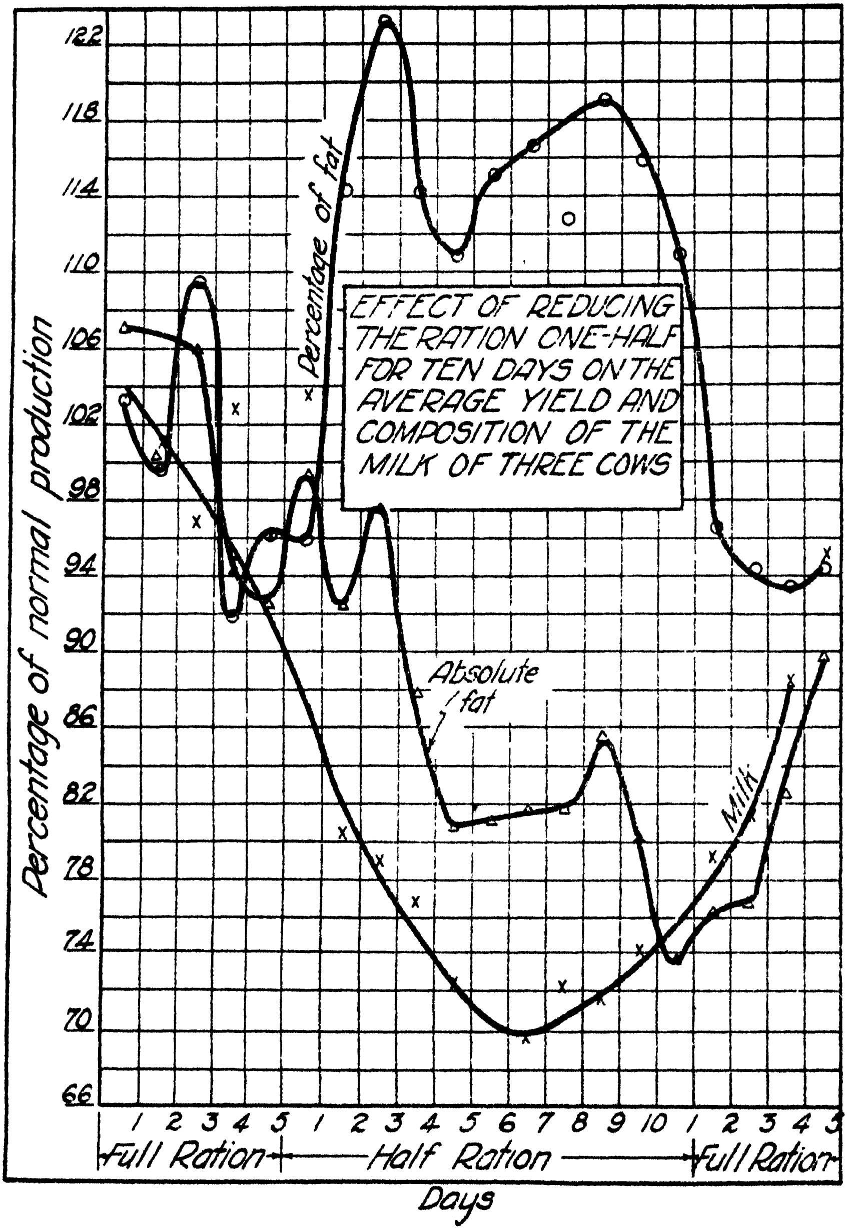
EFFECT OF REDUCING THE RATION ONE-HALF FOR TEN DAYS ON THE AVERAGE YIELD AND COMPOSITION OF THE MILK OF THREE COWS
Percentage of normal production
122
118
114
110
106
102
98
94
90
86
82
78
74
70
66
Percentage of fat
Absolute fat
Milk
1 2 3 4 5 1 2 3 4 5 6 7 8 9 10 1 2 3 4 5
Full Ration
Half Ration
Full Ration
Days

CHART 1

condition of the animals during the ten days of the reduction. One cow bloated during this period and showed a slightly increased temperature for three days.

These results show that there is a considerable increase in the per cent of fat during the second and third days following feed reduction. As only three cows were used, the results were checked by using a larger number of animals in varying stages of lactation. Table 2 gives a description of the cows.

During a three day preliminary a full feed was given similar to that previously fed and complete records were kept. The fourth day each constituent of the feed was cut exactly 50 per cent. This feed reduction was continued for three days, after which the plane of feeding was again returned to normal. Table 3 shows the results. It will be seen that the per cent of fat again showed a very decided increase by the third day on the reduced ration. This increase was followed by a decrease in the per cent of fat shortly after the feed was returned to normal.

TABLE 2

Description of cows

COW NUMBER	MONTH OF LACTATION	BREED	AVERAGE DAILY MILK PRODUCTION AT START OF EXPERIMENT
			pounds
64	2	Jersey	35
110	2	Jersey	25
121	8	Jersey	14
129	6	Jersey	24
275	4	Holstein	32
282	9	Holstein	19
288	9	Holstein	10
325	2	Ayrshire	34

The flow of milk did not appear to be reduced as much in this experiment as in the year previous. This is partly accounted for by the fact that some of the cows were more advanced in lactation and were not producing heavily. It appears that the cows producing large amounts of milk are affected more by the cut in the feed than those producing only a limited amount of milk.

The total fat production was not increased by the feed reduction as the milk flow was sufficiently reduced to counterbalance the effect of the increase in the per cent of fat.

The findings indicate that in the case of cows on yearly test the average per cent of fat during the two-day test can be influenced by reducing the feed of cows on test two days previous.

In view of the peculiar effect of underfeeding on the per cent of fat, this factor should be considered in interpreting data on the possibility of increasing the per cent of fat by the administration of drugs. If cows go off-feed due to the administration of drugs there is the possibility of the per cent of fat increasing due to the self-reducing plane of nutrition as well as to the influence of the drugs.

TABLE 3

The effect of feed reduction on milk secretion

DATE	AVERAGE DAILY MILK PRODUCTION—8 COWS	TRUE AVERAGE FAT—8 COWS	AVERAGE DAILY FAT PRODUCTION—8 COWS	MEAN ATMOSPHERIC TEMPERATURE FOR THE TWENTY-FOUR HOURS
		per cent		
March 12	23.02	4.805	1.106	50
March 13	24.61	4.514	1.111	57
March 14	24.98	4.384	1.095	60
March 15	24.70	4.700	1.161	60
March 16	22.08	4.524	0.999	47
March 17	21.20	5.137	1.089	58
March 18	21.51	4.826	1.038	64
March 19	23.56	4.334	1.021	70
March 20	23.76	4.192	0.996	69
March 21	23.50	4.268	1.003	41
March 22	23.07	4.516	1.042	43
March 23	22.56	4.486	1.012	48
March 24	23.17	4.536	1.051	55

The effect of underfeeding as it influences experiments of other types was shown very clearly in work being carried on at this station (3) to show the correlation between the atmospheric temperature and the per cent of fat in milk. The data up to the

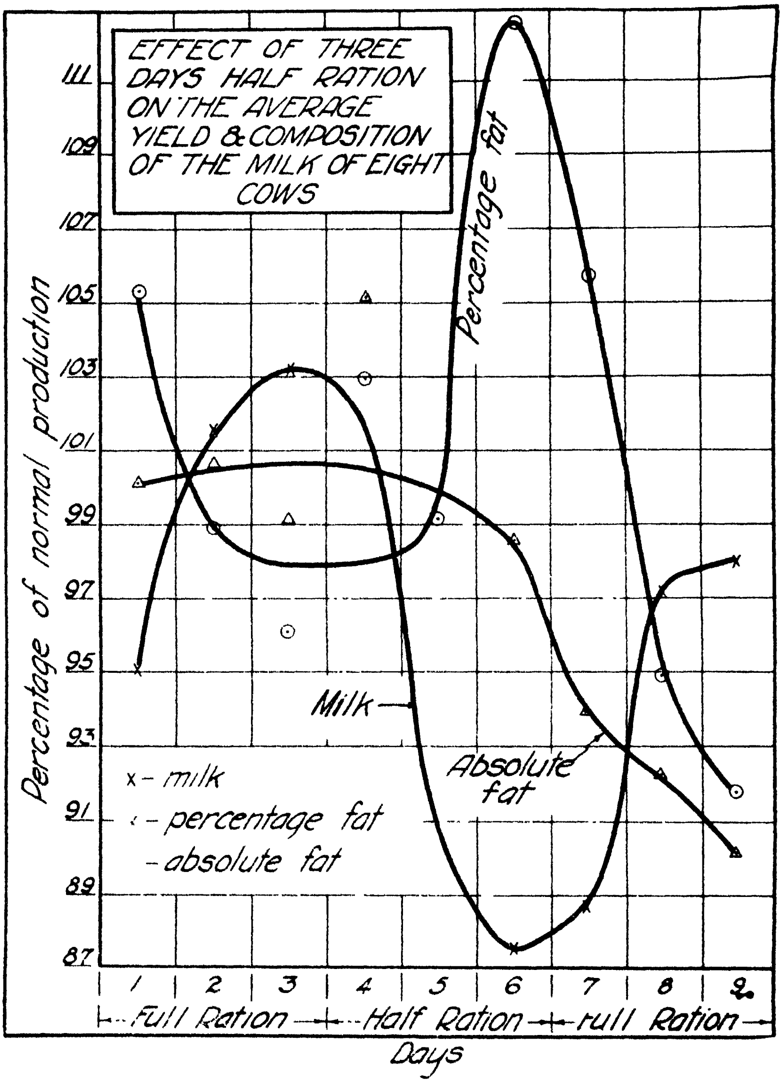

CHART 2

time the cows were placed on pasture indicate that there was a causative relation between temperature and the percentage of fat in milk, showing roughly an increase of about 0.15 per cent of fat for a decrease in the temperature of 10°F. The cows on this experiment were turned to pasture May 3, 1921. Table 4 shows that there was a significant increase in the per cent of fat following that day which could not be accounted for by the temperature. It is believed that the underlying cause of the increase was due to underfeeding resulting from the fact that

TABLE 4

The effect of pasture on the per cent of fat in milk

DATE	MEAN ATMOSPHERIC TEMPERATURE FOR TWENTY-FOUR HOURS	TOTAL MILK PER DAY AVERAGE 10 COWS	TRUE AVERAGE FAT PER DAY AVERAGE 10 COWS
			per cent
April 23	65	26.16	4.63
April 24	73	26.47	4.72
April 25	71	26.35	4.83
April 26	50	25.95	4.64
April 27	32	25.95	4.86
April 28	50	24.93	4.77
April 29	50		
April 30	53	25.72	4.73
May 1	46	25.37	4.85
May 2	46	24.6	5.26
Cows turned to pasture			
May 3	47	24.1	5.19
May 4	51	24.9	5.19
May 5	56	24.4	5.50
May 6	58	24.6	5.28
May 7	60	27.5	5.20
May 8	58	24.2	5.31
May 9	63	25.5	5.20
May 10	62	24.8	5.47
May 11	60	25.3	4.82
May 12	63	26.0	5.24
May 13	60	27.3	5.01

fresh pasture grass has a high water content which makes it impossible for a high producing cow to consume sufficient nutrients to satisfy her requirements. Furthermore it takes some time for the animals to become accustomed to foraging after stall feeding during the winter. This results in underfeeding for a short time with the resulting affect on the per cent of fat.

SUMMARY

It was shown that when the ration fed to dairy cows was reduced 50 per cent that there was a decided increase in the per cent of fat in the milk. The peak of the increase in the per cent of fat was reached about the third day. The per cent of fat remained abnormally high as long as the reduced ration was continued (ten days). When the ration was brought back to normal the per cent of fat decreased and remained below that of the preliminary period during the entire ten-day period.

The quantity of milk produced was reduced, the amount of reduction depending on the length of the feeding period and the stage of the lactation period.

The total yield of fat was not significantly changed.

Underfeeding did not appear to cause a feverish condition of the udder.

The effect of underfeeding should be taken into consideration in interpreting data on feeding trials of short duration, the effect of drugs on the per cent of fat, pasture experiments, and other experiments of this type where significance is placed upon a variation in the per cent of fat.

CONCLUSIONS

1. It is possible to materially increase the per cent of fat in the milk of cows during the two-day test made in connection with yearly semi-official records. Greater care should, therefore, be exercised by those in charge of this work to prevent advance information reaching the breeder as to the exact time the test will start.

2. As the total amount of fat is not materially increased, and may be decreased it is of little or no value to reduce the feed on a seven day test in an attempt to increase the total daily production of fat.

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COPPER IN DAIRY PRODUCTS AND ITS SOLUTION IN MILK UNDER VARIOUS CONDITIONS

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INTRODUCTION

There are many flavor defects in milk products that have been attributed by investigators to the presence of copper or other metals. Seldom is the flavor directly from the metal itself but through what has been supposed to be a catalytic effect some of the milk constituents are broken down and compounds with disagreeable odor and taste are produced.

In 1905 Golding and Feilman (1) described an "alkaline mealy flavor" which they found in certain samples of market milk. The trouble was traced to the use of a cooler from which the tin was worn thus exposing a copper surface; the presence of small amounts of copper dissolved in the milk together with the activity of certain organisms was believed to be the cause of the development of the peculiar flavor. The fact that the flavor was noted only after about sixteen to eighteen hours gave proof that it was not due to the copper salt itself, but that the copper in some way caused or assisted in a change which resulted in the formation of a substance which rendered the flavor objectionable. Rogers, Berg, Potteiger and Davis (2) investigated very thoroughly the flavor of butter obtained from cream which had been allowed to become contaminated with copper as well as iron. They found that "in every instance the scores on the control butters were better than the scores on the butter made from cream to which copper had been added, even in the small amount of 1 mgm. of copper per kilo of cream." Hunziker and Hosman (3) by allowing butter to stand in contact with certain metals and their hydroxides found tallowiness developing invariably when copper was the metal. Palmer and Combs (4) added copper lactate to cream in small amounts and proved that butter made from this cream became tallowy. Results similar to those just described have been reported also by Rosengren (5).

Olson (6) found that the action of rennet on milk was slowed down by the presence of copper and Gerber (7) reported that among other salts those of copper affected the rate of coagulation of milk by various vegetable and animal ferments.

Hess (8), and Hess and Unger (9) have recently discovered the interesting fact that where milk has become contaminated with copper the activity of the antiscorbutic vitamine is reduced.

Aside from the proof given in these published reports of investigations on the evil effects of copper contamination on milk products it is also well known that in the trade most of the unexplained defects in dairy products have been attributed to this factor, for instance, the strong flavor developing in powdered whole milk after a few months in storage has been thought by manufacturers to be caused at least partly by the presence of copper. Certain observations have been made in this laboratory also which indicate that unusually large amounts of copper in sweetened condensed milk can cause tallowiness in that product.

Changes brought about by the contamination of copper and other metals on foods other than dairy products have been demonstrated by various investigators particularly by Emery and Henley (10). They have pointed out what seems to be generally true, that the metals themselves do not bring about the decompositions except in presence of air or oxygen.

The activity of such metals as copper which assist in oxidative changes has led to the use of the term "oxygen carrier." The practice has long been made of adding copper in Kjeldahl digestions to hasten the oxidation of the organic material. The catalytic activity of copper in various organic and inorganic reactions is well known. Golding and Feilman (1) seemed to suspect that the defect which they noted in market milk resulting from copper contamination was related to an oxidative process since a similar flavor could be produced by adding oxidizing agents such as hydrogen peroxide. Also most of the investigators mentioned above have considered the changes from that point of view.

Since copper has been found to be such a dangerous impurity in milk products it seems important to know something about how it gets there in the first place, and with this knowledge to devise means of keeping it out if possible. Inasmuch as such equipment as pasteurizers, coolers, and sanitary pipe are usually constructed of copper coated with tin there is always the possibility of the tin wearing through, leaving the copper surface in contact with the milk. Furthermore in the manufacture of condensed, evaporated and powdered milk and ice cream mixes, copper hot wells and vacuum pans are ordinarily employed. Chemical analysis is not necessary to show that copper is dissolved by the milk from this equipment as it can always be noticed that the surface of a copper hot well or pan is brighter and smoother in appearance after contact with hot milk than before.

Copper as a normal constituent of cow's milk has been reported by some investigators while others have thought it not to be naturally present. Of course this might be expected to vary as the copper content of the feed of the cow changes. Some recent work by Supplee and Bellis (11) indicates that copper may be expected naturally in cow's milk to the extent of about 0.52 part per million on the average.

The purpose of this work was to consider whole milk merely as a solvent and to determine the amount of copper dissolved in the fluid when in contact with the metal under various conditions. From this point of view Golding and Feilman (1) made a few experiments to determine the influence of air on the solubility and it was found that bubbling air through the milk, or suspending copper gauze at the surface of the milk increased enormously the amount of copper dissolved. Upon pasteurizing milk in a copper vessel at 145°F. for one-half hour Hess (8) found the milk to contain "three or four parts of copper per million."

Donauer (12) by weighing strips of metal before and after contact with fresh milk, sour milk and 0.2 per cent lactic acid found much more of the metals dissolved at pasteurizing than at lower temperatures. Many of the metals, including copper, were attacked by fresh milk to about the same extent as sour milk. Also, Supplee and Bellis (11) made some observations on the amount of copper taken up by milk during handling in milk plants. Passage of milk through sanitary piping from which the tin was worn resulted in an increase in copper content as much as 2 mgm. copper per liter. Condensing in copper vacuum pans caused an increase in copper in the milk of from 0.38 to 2.98 mgm. per liter, and after storing milk in copper containers for twelve hours at 45°F. it was found to have taken up 1.21 mgm. of copper per liter, and for two hours at 150°F.—4 mgm. per liter.

EXPERIMENTAL

Except where otherwise stated, strips of pure copper were used giving 140 square inches of surface. After allowing 2000 cc. of good fresh milk to stand in glass flasks in contact with the metal under the conditions of the experiment, the milk was poured off and evaporated to dryness. The residue was ignited in a muffle furnace and the ash dissolved in a small quantity of nitric acid. The copper in solution was determined electrolytically, and in some cases where the quantity of copper was extremely small it was dissolved off the gauze electrode and run colorimetrically by the potassium ethyl xanthate method (13).

In making the electrolytic separation directly from the solution it was sometimes found that a good deposit was not obtained, so that the practice was adopted of depositing the copper first on one of the gauze electrodes, than after washing out the solution with water acid was added and the current reversed. In this way the cathode could be covered with a smooth deposit of good color.

Particular care was taken to have the water and all reagents used free from copper. In a great many of the experiments copper determinations were made on portions of the untreated milk as checks. All these analyses gave results very close to 0.5 mgm. per 1000 cc. and this figure was always subtracted from the results. The milk was obtained from the salesroom of the College of Agriculture and no observations were made as to the character of the equipment through which it had passed from the time it was drawn from the cow. Therefore, it could not be certain in this instance that the milk had not taken up some copper in handling. Yet it is interesting to note that the above figure is very near to that found by Supplee and Bellis as the amount of copper normally present in cow's milk.

All milk used in any given experiment was from a single composite sample. While each experiment in practically all cases represents a different tank of milk from every other one.

Effect of air and oxygen on the solvent action of milk

Experiment 1. Three portions of milk were heated at 140°F. with copper strips for one hour. In sample 1 the flask was merely shaken from time to time. Through 2 air was bubbled throughout the heating period and in sample 3 pure oxygen was passed similarly. Amount of copper dissolved by the milk in milligrams per liter follows:

	mgm
Sample 1	5 45
Sample 2	25.15
Sample 3	lost

While flask 3 was broken near the end of heating period it was apparent that an enormous amount of copper had been dissolved for the milk had become intensely blue.

These results substantiate those of Golding and Feilman showing that oxygen and air increase to a great extent the amount of copper dissolved by milk.

It should be noted in this connection that copper has been found (14) to be dissolved by organic acids only when a supply of air is afforded. However, this example is not exactly parallel to that of the action of milk since perfectly fresh milk is believed to contain no free organic acid. Also, Emery (15) has shown that oxygen assists in the solution of some metals in fats.

Solution from a smooth bright copper surface compared with one darkened by an oxide incrustation

Experiment 2. Half of the copper strips were coated with oxide by holding for an instant in the blue flame of the Bunsen; the others were well polished. By immersing in the milk for one hour at 140°F. the following amounts of copper were found to be dissolved in milligrams per liter:

	mgm.
Bright copper	5.45
Darkened copper	19.90

Experiment 3. In this case the copper strips were treated by immersion in chlorinated soda solution of a strength such as is usually employed in milk plants for disinfecting purposes. The strips were then dried in air, which caused the surface to become quite dark. The milk in contact with the copper was boiled for one and one-half hours, and the following amounts of copper were dissolved per liter of milk:

	mgm.
Bright copper	5.35
Darkened copper	26.50

Experiment 4. This experiment was run at the same time in exactly the same way as experiment 3 except that the milk contained 18 per cent sugar. The following results were obtained.

	mgm.
Bright copper	6 45
Darkened copper	20.60

These experiments show the ease with which copper dissolves from a corroded surface of copper as compared with a well polished surface.

The fact that air increases the solvent power of milk is no doubt related to the fact that copper dissolves from a surface coated with oxide more readily than from a polished surface. It can always be noticed that where milk is heated in a copper vessel there is very soon formed a streak of dark copper near the surface of the milk. By covering this with milk it is soon dissolved and a new ring forms again at the surface. It is entirely probable, therefore, that air assists in the solution of copper in milk by continually corroding the surface, thus rendering the copper more readily dissolved.

Relation of carbon dioxide to the solvent power of milk

Generally carbon dioxide is considered to increase the dissolving power of solutions. This gas is known to increase the solubility of copper in water and in some salt solutions though it greatly decreases the solubility of copper in ammonium chloride solution (14). Milk contains a considerable proportion of this gas, so the following experiments were carried out to determine if this might be a factor in the reaction.

Experiment 5. Four thousand cubic centimeters of milk was heated and by applying vacuum and agitation the gases were removed as much as possible. This was divided and cooled. Half of it was saturated with carbon dioxide by bubbling the gas for a long time. The two portions were heated with copper strips at 140°F. for one hour. Milligrams of copper dissolved per liter were as follows:

	mgm
Saturated with carbon dioxide	4.80
Not so treated	7.65

Experiment 6. Two portions of milk were heated at 140° for one hour with copper. In one case carbon dioxide gas was bubbled through the milk during the heating period and in the other case nitrogen gas. The latter was taken as a check so that approximately the same degree of agitation could be effected in the two cases; the solvent power of the milk should not be changed by the nitrogen. Following are the amounts of copper dissolved in milligrams per liter.

	mgm.
Passing carbon dioxide	9.05
Passing nitrogen	9.70

Experiment 7. On another occasion two 2000-cc. portions of milk were boiled with copper strips for two and one-half hours.

In one case carbon dioxide was bubbled through the milk throughout the heating period, and in the other case no gas used. Following are the results in terms of milligrams copper per 1000 cc. of milk.

	mgm.
Passing carbon dioxide	17.5
No gas	17.9

These experiments show beyond doubt that carbon dioxide has no influence on the solvent power of milk. The milk used in experiment 7 showed a much greater solvent action on copper than most of the samples used, there was apparently no explanation for this variation. However, the comparison of the check against the portion with carbon dioxide is very similar to the results in experiment 6.

Effect of amount of surface exposed and the time of contact with the metal

Experiment 8. A series of 3 samples were run as follows:

Sample 1— 70 square inches of copper, two and one-half hours boiling.
Sample 2—140 square inches of copper, two and one-half hours boiling.
Sample 3—140 square inches of copper, one and one-quarter hours boiling.

The quantities of copper dissolved were:

Sample 1—1.45 mgm. per liter.
Sample 2—4.10 mgm. per liter.
Sample 3—2.95 mgm. per liter.

On account of the wide limits of error in these results no conclusions should be drawn quantitatively. However, it is evident that the more surface of copper exposed and the greater the time of exposure the more copper will be dissolved, and if there is a limit to the amount of copper the milk will dissolve it has not been found in this experiment.

Effect of temperature on the amount of copper dissolved

Experiment 9. Determinations were made at three temperatures. In each the milk was in contact with the copper for two and one-half hours, the strips being dropped in after the temperature of the milk was brought to the desired point. The following were the quantities of copper in milligrams dissolved per liter of milk:

	mgm.
Room temperature	6.00
145°F	14.15
Boiling	4.45

Experiment 10. The results of experiment 9 seemed so extraordinary that another experiment was run in exactly the same way. The following results were obtained:

	mgm
Room temperature	4.95
145°F	11.30
Boiling	3 85

Experiment 11. Still another run was made as in the two preceding experiments except that the temperatures of boiling and 145°F. only were used. Quantities of copper per liter were as follows:

	mgm
At 145°F	16.25
Boiling	5 35

It is evident from these experiments that milk attacks copper much more readily at 145°F. than at boiling temperature and also that there is but little difference between the amount dissolved at room temperature and at boiling. In this connection it might be pointed out that Carnelley (16) has shown that copper dissolves in water and in some salt solutions less readily at boiling than at lower temperatures. Also Emery (15) found that the rate of solution of certain metals in fats was independent of the temperature.

On the other hand, it appears that the question is not quite so simple as this as will be shown in the next experiment.

Experiment 12. Four thousand cubic centimeters of milk was boiled for thirty minutes, cooled, and the water which was lost on evaporation was replaced. This was divided and through 2000 cc. air was bubbled for fifteen minutes. Both of these portions were heated at 145° with copper for two and one-half hours and at the same time 2000 cc. of the same milk unboiled was heated with the same amount of copper for the same time and at the same temperature. The following results show the amounts of copper dissolved per liter of milk in milligrams:

	mgm.
Boiled, cooled and saturated with air	5.45
Boiled, cooled, no treatment	5.35
Not boiled	16.25

This experiment shows that by boiling the milk something is destroyed or transformed thus reducing the solvent power of the milk. It was at first thought that this might be explained on the basis of a removal of air by boiling, and that was the reason for introducing air into one of the boiled portions in the above experiment. However the results show that this would not explain the difference in activity between boiled and unboiled milk. Yet another experiment was carried out to surely prove the point:

Experiment 13. Four thousand cubic centimeters of milk which had been boiled for some time was cooled to 145°, divided, and air bubbled through half of it for one hour. Both portions were than heated with copper for two and one-half hours at 145°F. Amounts of copper dissolved per liter of milk were as follows:

	mgm
Saturated with air	5.45
Check	5.60

Effect of the addition of sucrose on the solvent action of milk

In the manufacture of sweetened condensed milk there is ordinarily added to the milk in the hot wells 18 per cent sugar which solution is drawn into the vacuum pan for condensation.

Experiment 14. In sample 1 milk with no addition dissolved from smooth bright copper strips in one and one-half hours at boiling 5.35 mgm. copper per liter, while in the sample containing 18 per cent sucrose under the same conditions 6.45 mgm. of copper was dissolved. Again using copper strips which had been darkened by immersion in chlorinated soda solution and drying in air, milk with no addition dissolved 26.5 mgm. copper per liter while milk with sugar dissolved 30.6 mgm.

The addition of sucrose to the milk in the manufacture of sweetened condensed milk increases but little the amount of copper dissolved.

Effect of the acidity of the milk on the amount of copper dissolved

Experiment 15. A sample of fresh milk with acidity of 0.16 per cent was allowed to act on copper at 140°F. for one hour when it was found that 5.45 mgm. copper was dissolved per liter, and the same milk allowed to stand in the laboratory until it reached 0.2 per cent acidity dissolved under the same conditions 6.55 mgm. copper.

Experiment 16. A portion of the same milk used in experiment 12 was allowed to stand at room temperature until the acidity had reached 0.216 per cent. (The original milk titrated 0.162.) This sample was then heated with copper at 145°F. for two and one-half hours. The amount of copper dissolved per 1000 cc. of milk was found to be 5.65 mgm.

From these experiments it must be concluded that slight increases in acidity of the milk do not greatly increase the amount of copper dissolved; in fact the amount of copper dissolved was actually reduced in the last experiment. Inasmuch as the acidity of the samples of milk in these experiments was much lower than would be found in very sour cream and buttermilk, conclusions should not be drawn from these results as to the behavior of those products.

Distribution of copper between the cream and the skim milk fractions

Experiment 17. Six thousand cubic centimeters of whole milk was heated with copper some air being passed into the milk at the same time in order that a considerable quantity of copper would be dissolved. Four thousand cubic centimeters of this was put through a hand separator and in this way there was obtained

875 grams of cream testing 20.2 per cent fat and 5.94 per cent solids not fat, and 3110 grams of skim milk testing 0.1 per cent fat and 9.2 per cent solids not fat. The total amounts of copper found were 27.5 mgm. in 2000 grams of whole milk; 7.8 mgm. in 875 grams cream and 27.8 mgm. in 3110 grams skim milk.

First of all, these results show that there was a loss of copper in the separator—4000 cc. of whole milk contained 55 mgm. copper, but in the cream and skim together there was found only 35.6 mgm. From this it would seem that a considerable part of the copper must have become insoluble and gone into the slime.

In order to make further comparisons some calculations were made from the above results as follows:

	CREAM	SKIM
	mgm	*mgm*
Copper per kilo of fraction	8.9	8.9
Copper per 100 grams of fat	4.4	894.0
Copper per 100 grams of solids not fat	15.0	9.7
Copper per kilo of water	12.0	9.9

From these calculations it is seen that the copper distributes itself between the cream and skim fractions in proportion to the weight of the fraction itself and quite closely to the distribution of the water. From this it would seem that the copper is merely dissolved in the water.

There is one point of certainty from these results—that the copper does not distribute itself with the fat and, therefore, is not dissolved in the fat as was assumed by Donauer (12). Similarly, it was shown by Rogers, Berg, Potteiger and Davis (2) that although excessive amounts of iron in cream affected the quality of butter made therefrom, yet most of the iron went into the buttermilk fraction. In order to have an agency acting upon fat it is not necessary to suppose that it dissolves in the fat, it may be dissolved in the moisture incorporated in the fat or be adsorbed at the surface of the fat globules. It has been found in this laboratory that upon separation of a quantity of milk most of the lipase is found in the skim milk.

Also, it has been pointed out by Beatty (17) that pancreatic lipase is "entirely insoluble in fats, fatty acids and solutions of fats in ether, yet it acts on these bodies."

On the other hand Watson has shown that copper does dissolve in certain oils (14). It is evident, therefore, that considerable work should be done along this line before conclusions can be drawn as to the agency in the milk most important in dissolving the metals.

Electrochemical relations between copper and tin

In the electrochemical series of elements copper is somewhat below tin, consequently tin replaces copper in solution, the latter plating out. There is the possibility, therefore, that milk with dissolved copper upon coming in contact with tin may lose some of the copper. Commercial condensed and evaporated milk in tin cans would thus in time become lower in copper content, also milk equipment with both copper and tin surfaces exposed to the milk will yield less copper to the milk than a copper surface alone. This effect is shown in the following experiments.

Experiment 18. Four thousand cubic centimeters of milk was boiled with copper in order to get as much of the metal in solution as possible. Half of this was then boiled for two and one-half hours with strips of tin. Amounts of copper per liter in milligrams were as follows:

	mgm
Original half	33 9
Boiled with tin	28.4

Experiment 19. Two liters of milk was boiled with copper strips amounting to 140 square inches, the flask at the same time containing tin strips sufficient to give 80 square inches of surface. At the same time an equal quantity of the same milk was boiled with an equal amount of copper but without the tin. Copper dissolved per liter of milk was found to be as follows:

	mgm.
Without tin	17 9
With tin	6.7

The results of these two experiments show what was postulated from theoretical considerations: (*a*) That copper once dissolved in the milk may plate out on any tin surface with which it may later come in contact and (*b*) that where milk is exposed to surfaces of tin and copper together, less copper is dissolved than where there is the same exposure of copper without the tin. The latter condition would be found in copper equipment plated with tin but from which the tin had been worn in places exposing the copper surface. Under such conditions it would be expected that very little copper would be dissolved but through the same electrochemical effect the tin would be dissolved even more rapidly than from a tin surface alone.

Copper in commercial samples of condensed and evaporated milk

Copper was determined in 10 samples of sweetened and 6 of evaporated milk representing 9 brands. The amount of copper per kilo varied from 2.4 to 4.8 mgm. Average forall samples was 3.7. Taking 0.5 mgm. per liter as the amount of copper naturally present in cow's milk it is evident that the milk had added considerable quantities of copper in the process of manufacture. However, as has been demonstrated in the preceding experiment it is entirely possible (and judging from earlier experiments it would seem probable) that more copper had dissolved in the milk during manufacture, then, later in contact with the tin of the container some of the metal was lost from solution through electrochemical action.

SUMMARY AND CONCLUSIONS

1. The unfavorable effect of the presence of copper and other metals in milk and its products has been thoroughly demonstrated by many previous investigators.

2. Since the equipment used in most dairy manufacturing operations is made of copper, it is important to know something of the conditions under which the copper dissolves in the milk and to learn, if possible, how it can be reduced to a minimum.

3. The presence of air and oxygen was here found to increase enormously the amount of copper dissolved by milk. Therefore, open pasteurizers, coolers, and holding tanks would be expected to yield much more copper than vacuum pans, and it would be much more important to have these of non-copper material.

4. Copper corroded with an oxide surface yields much more of the metal to the milk than smooth bright copper. It is particularly important to keep such equipment clean and well polished. Since the chlorine disinfectants such as chlorinated soda are usually active in corroding copper surfaces, their use should be avoided on copper hot wells and vacuum pans.

5. Carbon dioxide does not influence the dissolving power of the milk.

6. The amount of copper taken up by the milk increases with the amount of copper surface exposed and with the time of exposure.

7. About the same amount of copper is dissolved in the milk at room temperature as at boiling; at 145°F. considerably more copper is dissolved than at either. Therefore, in the manufacture of condensed and evaporated milk where copper hot wells are employed it is important to bring the temperature of the milk to boiling as rapidly as possible.

8. Inasmuch as milk once boiled dissolves about the same amount of copper at 145°F. as at boiling temperature, some transformation or loss of the agency which attacks the copper is indicated.

At the present time no conclusions can be drawn as to the cause of this phenomenon. It has only been shown that replacing the air in boiled and cooled milk does not reëstablish the same solvent power exhibited at 145°F. in unboiled milk.

9. The presence of 18 per cent sugar does not increase more than a little the amount of copper dissolved by milk. The amount of copper dissolved from pans and hot wells in the manufacture of sweetened condensed milk is not, therefore, much greater than in other manufacturing operations.

10. Milk slightly sour dissolves but little more copper than normal milk.

11. On passing milk containing copper through a separator, the metal distributes itself between the cream and skim milk fractions approximately in proportion to the water. It would seem, therefore, that it is dissolved in the water. The results show conclusively that the copper does not go with the fat, and is, therefore, not dissolved in the fat.

12. Analyses of commercial samples of condensed and evaporated milk indicate that copper is taken up in considerable quantities in the manufacture of these products.

13. From theoretical considerations and from experimental results it was shown that copper may be lost from milk to tin when it comes in contact with this metal, and also that less copper is dissolved when the milk is exposed to surfaces of copper and tin together. Consequently, it would be expected that condensed and evaporated milk would lose some of its copper to the tin of the container and consequently a can purchased on the market would show somewhat less copper in solution than was present at the time of manufacture. Also a copper cooler or pasteurizer imperfectly tinned would yield less copper to solution than if the milk were exposed to the same surface of copper without the tin.

On the basis of the same theoretical considerations the tin should dissolve in the milk much more rapidly when in contact with the copper, which would in part account for the rapid wearing of tin from such equipment. The latter point however, is not supported by any experimental evidence in this paper, no determinations for tin having been made in any samples.

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SOME FACTORS INFLUENCING QUALITY IN GELATIN AND THE USE OF THE FERMENTATION TEST AS AN INDEX OF BACTERIAL CONTAMINATION

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The consideration of quality of gelatin involves two large general questions. First, that the gelatin be free from metals and other substances injurious to health. Second, that it have a low bacterial content, free from undesirable organisms, a clear color, desirable odor, pleasant taste, low acidity and high jelly strength or water absorbing quality. The first of these questions is well taken care of by the Federal and State laws and are such that it is relatively easy for the gelatin manufacturer to comply with. It is but recently that much attention has been paid to the second question and interest is increasing, especially in regard to bacterial content and jellying powers. The second question is what is to be considered in this paper.

Fifteen samples of gelatin were secured in 5-pound lots from gelatin manufacturers, the object of the purchase was unknown to them. The total bacterial count was determined upon standard nutrient agar plus 1 per cent of lactose. The colon count determined upon the medium recommended by Ayers and Rupp. The fermentation test was run parallel with the plates and made in the following manner: 10 grams of gelatin were weighed aseptically into 100 cc. of sterile distilled water containing 1 gram of lactose. The temperature used to hasten the dissolving of the gelatin was 50°C., with sterile pipettes transferred to sterile tubes allowed to solidify and incubate at 28°C. for eighteen hours and 20° for thirty-six hours. The plates were incubated at 25°C. for thirty-six hours. The work was done in triplicate and repeated twice and the average results obtained shown in table 1.

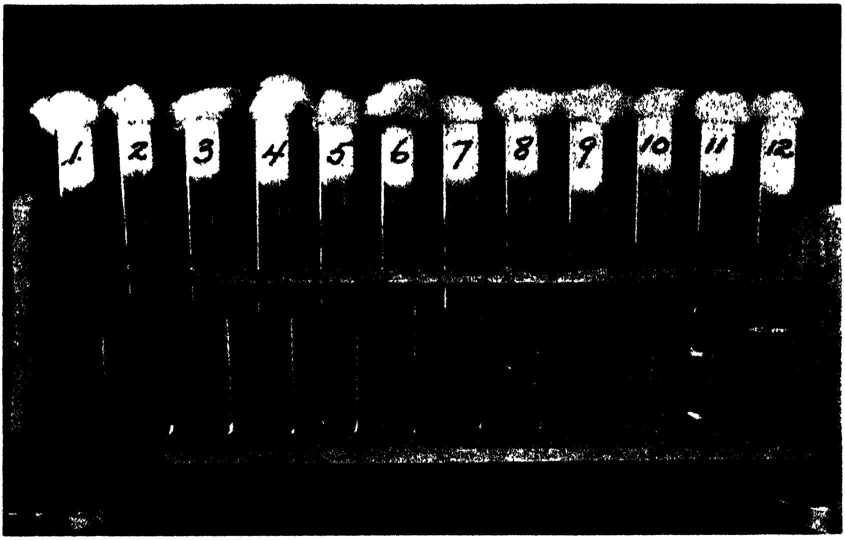
From the foregoing it can be concluded that the fermentation test can give the ice cream maker or user of gelatin an index of the bacterial contamination of the gelatin under consideration. Liquification in some degree showed in all samples where the bacterial content was greater than 5000 and gas bubbles in all cases where the colon content exceeded 100. It is hoped in further studies to determine what the various steps in gelatin manufacture affect the total bacterial count and colon content and to study if high bacterial content causes any lessening of the value of gelatin.

TABLE 1

GELATIN NUMBER	TOTAL BACTERIA	COLON COUNT	FERMENTATION REACTION	
			Liquification	Gas
1	750,000	200,000	++++	++++
2	1,500	Less than 100	–	–
3	2,600	Less than 100	–	–
4	5,000	Less than 100	–	–
5	200	Less than 100	–	–
6	100	Less than 100	–	–
7	5,000,000	600,000	++++	++++
8	2,000,000	750,000	++	++++
9	10,000	400	+–	+
10	450,000	50,000	++	++++
11	500,000	2,000	+	+++
12	60,000,000	35,000,000	++++	++++
13	500	Less than 100	–	–
14	500	Less than 100	–	–
15	70,000	4,200	+	++

JELL STRENGTH AS A FACTOR IN DETERMINING QUALITY

It is believed that the jell strength of gelatin or its water absorptive properties are of importance, in the standing up powers of ice cream. Eleven samples of gelatin were tested for jell strength in the following method: (1) By preparing definite strength solutions of gelatins, viz., 1 to 1.5 to 2 per cent and so on and allowing these solutions to remain for 12 to 16 hours at 20°C.; (2) by preparing a 10 per cent solution and pouring it out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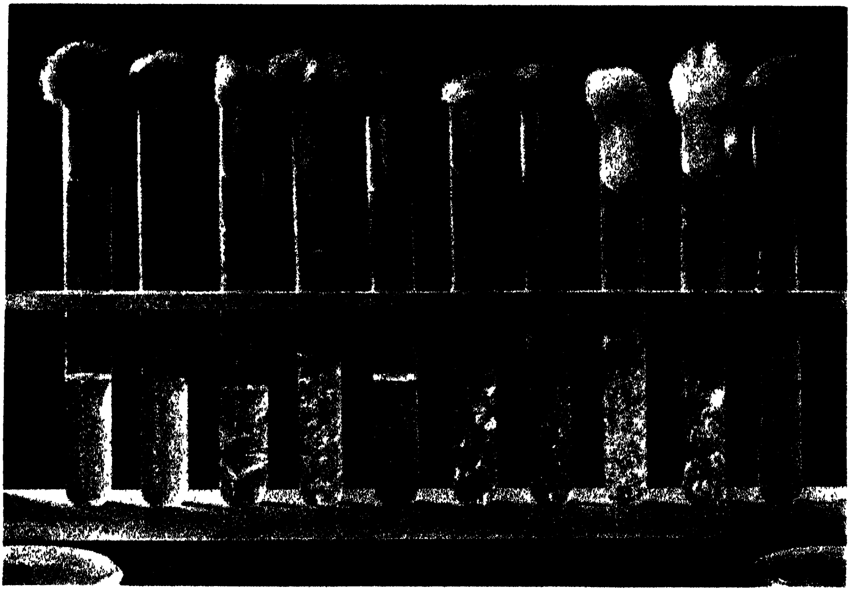

on Petri dishes, allowing them to remain five hours at 20°C. The method of determining jell strength by method 1 was by inverting the tube and in method 2 by pressure of the thumb. Method 2 was found unsatisfactory in that there was too great a chance for error upon the part of the operator.

By referring to table 1, notice that gelatins 2, 3, 4, 5 and 6 were low in bacterial content. By the use of the thumb test, the operator could not detect a difference of less than 2 per cent in jell strength. It has been found that the second method or thumb test is used by ice cream men to determine jell strength quite extensively but from this work is not to be recommended.

TABLE 2

GELATIN NUMBER	PER CENT GELATIN REQUIRED TO JELL IN DISTILLED WATER AT 20° FOR SIXTEEN HOURS
2	2.5
3	2.5
4	1.5
5	1.5
6	2.0
7	20.0
8	5.0
9	5.0
10	5.0
11	4 5
12	4.0

The range of hydrogen-ion concentration in the 15 samples of gelatin varied from 4.86 to 7.33 measured electrometrically and titrable acidity from zero to 8.0 cc. $\frac{N}{10}$ NaOH per 25 cc. of a 10 per cent solution of gelatin using phenophthalein as an indicator, but the pH or titrable acidity showed no effect upon bacterial count or jell strength.

ODOR AND TASTE AS A MEASURE OF QUALITY

The odor and taste were determined in 10 per cent solutions and it was found that gelatin 12 which had such a high bacterial content was but very little off in flavor and odor, while gelatin 9 was badly off in flavor and odor but showed a relatively low bacterial count. While it is desirable to have good flavor and odor upon gelatin believe that too much emphasis can be put on this factor relative to its value.

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THE BACTERIAL CONTENT OF SOME KANSAS ICE CREAM

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INTRODUCTION

For the past three years the Dairy Department of the Kansas State Agricultural College has conducted an ice cream scoring contest, open to all manufacturers of ice cream, marketing their product in Kansas. A few of the samples entered were especially prepared and represented the best product of the plant. The majority of the manufacturers, however, submitted samples that represented their regular product as sold on the market. A few of the contestants were manufacturers residing outside the state, but were marketing at least a part of their product in Kansas.

The score card used in these contests allowed a perfect score of 20 points for ice cream containing not more than 20,000 bacteria per gram. The bacterial analyses were made by the Bacteriology Department of the Kansas State Agricultural College and the data thus obtained afforded an opportunity to study the bacterial content of ice cream as it is sold in the state of Kansas.

METHOD OF ANALYSIS

A ¼-inch layer of ice cream was discarded from the surface of each container in order to eliminate surface contamination. The sample for bacteriological analysis was then taken with a sterile butter sampler. Two cores were removed from the entire depth of the ice cream; one from the center and one near the edge of the can. These cores were placed in a sterile bottle and the bottle submerged in water at 45°C. for five to ten minutes until the ice cream had melted. A gravimetric sample was obtained by adding 10 grams of the melted ice cream directly in 90 cc. of sterile, normal saline. From this, appropriate dilutions were made.

The plates were made and incubated according to the "Standard Methods for Bacteriological Examination of Milk," as recommended by the American Public Health Association in 1921. All determinations are on a gravimetric basis and therefore, represent the number of bacteria per gram of ice cream as determined by the official plate count.

RESULTS OBTAINED

Table 1 shows the bacterial counts, arranged in the order of the number of bacteria per gram, of all the samples analyzed in the three contests.

The samples numbered 1 to 39 inclusive were from the 1922 contest; those number 40 to 67 inclusive from the 1921 contest, and those numbered 68 to 115 inclusive from the 1923 contest.[1] The average number of bacteria per gram in all the samples was 1,895,000. The average for the 1921 contest (28 samples) was 1,383,428 per gram. The average for the 1922 contest (39 samples) was 1, 992, 461 per gram. The average for the 1923 contest (48 samples) was 2,114,239 per gram.

The following observations may be made from the table.

10 samples or 8.7 per cent contain 5,000 or less bacteria per gram
22 samples or 19.1 per cent contain 20,000 or less bacteria per gram
42 samples or 36.5 per cent contain 50,000 or less bacteria per gram
57 samples or 49.6 per cent contain 100,000 or less bacteria per gram
75 samples or 65.2 per cent contain 200,000 or less bacteria per gram
86 samples or 74.8 per cent contain 300,000 or less bacteria per gram
90 samples or 78.3 per cent contain 500,000 or less bacteria per gram
98 samples or 85.2 per cent contain 1,000,000 or less bacteria per gram
17 samples or 14.8 per cent contain more than 1.000,000 bacteria per gram

It will be observed that only 22 or 19.1 per cent of the samples could be given a perfect score for bacterial content according to the score card. It may also be noted that only 14, or 12.1 per cent, of the samples contained more than the *average* number of bacteria.

[1] The results for the year 1921 were obtained by Prof. O. W. Hunter.

The counts for these 14 samples were so high that it raised the average for the group to nearly 2,000,000 per gram. The average count in such a class of variables is not of much significance because of the irregularity introduced by these few individuals. The middle class in such a set of variables is perhaps a better index than is the average count. Since there are 115 samples in this series, the middle class would be between the fifty-seventh and fifty-eighth samples. It will be noted that the bacterial count of this class would be close to 100,000 per gram.

The state laws of Kansas require that all materials used in the manufacture of ice cream be pasteurized at 145°F. for thirty minutes. The evidence here presented indicates that it is possible, under Kansas conditions to place on the market a product having a consistently low bacterial count.

FACTORS INFLUENCING BACTERIAL CONTENT OF ICE CREAM

Products. There are several factors which must be taken into consideration in the manufacture of ice cream having a low bacterial content. The products used in making the mix should be of high quality and contain a relatively small number of organisms. Gelatin, skim milk powder, butter, cream, and milk are usually the most important factors contributing to a high bacterial content in the raw mix. If these products are of poor quality and contain large numbers of bacteria, the mix is sure to have a high bacterial count before pasteurization. This is especially true of the cream, which is frequently found to contain several millions of organisms per gram. Some manufacturers are obliged to buy cream from small producers who do not market their product every day. This usually results in the use of cream having a very high bacterial count, which in turn will affect the initial count of the mix and also the final count of the ice cream. For example, if the raw mix contains 30,000,000 bacteria per gram as a result of using a poor quality of raw product, the bacterial count after pasteurization is certain to be high. With 99 per cent efficiency of pasteurization there would remain 300,000 bacteria per gram. The only remedy for this condition is to purchase raw materials of better quality. If the ice cream is not made from clean wholesome products, it will be manifested in the high bacterial count of the finished product.

Pasteurization. The efficiency of pasteurization is perhaps the most important factor in controlling the bacterial content of ice cream. If the mix is held at 145°F. for not less than thirty minutes it is reasonable to expect 99 per cent efficiency in the destruction of organisms. With a mix containing 5,000,000 bacteria per gram, 99 per cent reduction would leave 50,000 bacteria per gram after pasteurization. On the other hand if the time is cut down to twenty minutes, about 75 per cent efficiency of pasteurization would be the result. With this hypothesis there would remain 1,125,000 bacteria per gram after pasteurization instead of 50,000. The ice cream from such a mix is destined to have a high bacterial count and will score 18 to 20 points lower than a properly pasteurized product. This loss of quality is due to a saving of ten minutes of time. In many instances the high bacterial content of ice cream may be traced directly to reduced time of pasteurization by the manufacturer. After the mix leaves the pasteurizer there is slight increase in the number of bacteria as a result of homogenizing. This is probably due to the breaking up of clumps of bacteria.

Ageing. Unpublished data from experimental work, carried on at this station under plant conditions, shows no material increase during the ageing process, when the temperature conditions were properly controlled. By keeping the temperature at 40°F. or below, the growth of bacteria can be checked very effectively. Failure to control the temperature during this process is very frequently the cause for high bacterial counts in ice cream. A difference of only a few degrees may mean a million more organisms per gram in the finished ice cream.

Freezing. During the freezing process there is sometimes observed a slight increase in the number of organisms. This is frequently within the limits of experimental error and may not be detected. Such an increase in the number of organisms would probably be due to the breaking up of clumps of bacteria as a result of the whipping of the mix, or to contamination from the freezer.

Storage. From the time the ice cream enters the hardening room until it is consumed there is a very slight, gradual reduction in the number of organisms due to the destruction of the types that are unable to withstand the low temperature. In general it may be said that under properly controlled conditions, there will be a slight increase in the bacterial content of the finished product, over that of the mix as it leaves the pasteurizer. This increase, however, is too small to explain some of the high counts reported in table 1.

Utensils. Another factor that should not be onverlooked is the contamination of the mix from the utensils. Ice cream mix comes in contact with many utensils during the process of manufacture. If the cans, vats, pipe lines, and freezers are not properly steamed, they may be a very important source of contamination. To cite a concrete example from a Kansas plant, an ice cream mix before being placed in the freezer had a bacterial count of 26,000 per gram. After freezing it contained 625,000 per gram. Some of this increase may have been due to the breaking up of clumps of bacteria, but most of it was probably due to a poorly washed freezer.

SIGNIFICANCE OF THE BACTERIAL COUNT OF ICE CREAM

The bacterial count of ice cream is perhaps a better index to the conditions surrounding its production than is the count on any other dairy product. This is especially true of milk. Even though milk is produced under ideal conditions, if it is held at favorable temperatures the bacteria will grow so rapidly that there may be millions of organisms present in a few hours. The bacterial count of milk as it is placed on the market, therefore, may not be directly proportional to the sanitary conditions surrounding its production. The development of organisms in ice cream subsequent to its manufacture is practically eliminated as a result of the low temperature at which it is held. A bacterial analysis made at any time should not greatly exceed the initial count when the ice cream left the freezer. This fact renders the determination of total numbers of bacteria in ice cream particularly valuable, since it reveals the condition of the product when

TABLE 1

The bacterial count of 115 samples of Kansas ice cream

LINE NUMBER	SAMPLE NUMBER	OFFICIAL PLATE COUNT PER GRAM OF ICE CREAM	LINE NUMBER	SAMPLE NUMBER	OFFICIAL PLATE COUNT PER GRAM OF ICE CREAM	LINE NUMBER	SAMPLE NUMBER	OFFICIAL PLATE COUNT PER GRAM OF ICE CREAM
1	115	1,500	39	65	45,000	77	27	215,000
2	104	3,000	40	93	46,000	78	111	220,000
3	113	3,000	41	5	49,000	79	48	225,000
4	35	4,000	42	21	49,000	80	33	228,000
5	112	4,000	43	87	52,000	81	83	240,000
6	40	5,000	44	91	52,000	82	66	250,000
7	42	5,000	45	106	53,000	83	39	262,000
8	62	5,000	46	84	67,000	84	7	284,000
9	79	5,000	47	4	74,000	85	34	300,000
10	100	5,000	48	86	75,000	86	49	300,000
11	89	6,000	49	16	77,000	87	38	343,000
12	26	7,000	50	98	80,000	88	45	350,000
13	32	7,000	51	99	80,000	89	43	500,000
14	64	8,000	52	9	85,000	90	52	500,000
15	13	14,000	53	20	86,000	91	14	600,000
16	102	14,000	54	12	87,000	92	53	600,000
17	107	14,000	55	96	90,000	93	82	620,000
18	2	15,000	56	24	100,000	94	76	660,000
19	10	15,000	57	41	100,000	95	22	700,000
20	101	16,000	58	17	109,000	96	67	700,000
21	55	20,000	59	92	110,000	97	105	720,000
22	94	20,000	60	110	110,000	98	60	900,000
23	41	23,000	61	8	122,000	99	69	1,100,000
24	114	23,000	62	103	125,000	100	108	1,300,000
25	23	25,000	63	68	136,000	101	81	1,600,000
26	44	25,000	64	78	145,000	102	3	2,000,000
27	47	25,000	65	15	150,000	103	57	3,000,000
28	11	29,000	66	59	150,000	104	19	4,000,000
29	95	30,000	67	75	150,000	105	80	4,000,000
30	28	33,000	68	90	155,000	106	73	4,500,000
31	37	34,000	69	31	188,000	107	109	5,000,000
32	36	36,000	70	25	200,000	108	61	10,000,000
33	85	36,000	71	50	200,000	109	71	16,000,000
34	88	37,000	72	51	200,000	110	72	16,500,000
35	6	38,000	73	54	200,000	111	18	18,000,000
36	97	40,000	74	56	200,000	112	63	20,000,000
37	1	41,000	75	58	200,000	113	29	22,000,000
38	70	41,000	76	77	200,000	114	30	27,000,000
						115	74	47,000,000

it was produced. If carelessness prevails at any point in the production of ice cream, or if it is made from materials of poor quality, the finished product is almost certain to have a high bacterial count.

The 17 samples reported in table 1, having more than 1,000,000 bacteria per gram, certainly were not produced under carefully controlled conditions. At some point in the manufacturing process, the bacterial growth was not checked. The bacterial count does not reveal what was responsible, but it does indicate that carelessness has prevailed in one or more points in the manufacturing process. This fact alone should prohibit the sale of such a product.

The increasing popularity of ice cream; its change of status from that of a delicacy to that of a staple human food; and its large use by children and by the sick, makes it imperative that the conditions surrounding its production be controlled by legislation. The establishment of legal standards limiting the bacterial content of dairy products, is an effort to protect the consumer against the use of foods that are not properly handled. It does not necessarily mean that milk, ice cream, etc., that contain more than a certain number of organisms are dangerous to use. It does mean, that if the food contains more bacteria than the legal standard, carelessness has prevailed at some point in the production or marketing. This is the factor that the legal standard seeks to exclude.

It is not the purpose of this paper to suggest a legal standard for ice cream. The establishment of a standard should be made only after a thorough study of the manufacturing process under commercial plant conditions. Such a study is now in progress at the Kansas Experiment Station. Whatever the standard may be, it should be fair to the manufacturer and yet necessitate careful handling in every operation. It should make necessary the use of clean, wholesome products of good quality and low bacterial content. The standard should be low enough to exclude ice cream made from products that have not been efficiently pasteurized. It should make it necessary to control the temperature of the mix during the ageing process, and to use utensils that have been thoroughly cleaned and steamed. A legal standard should be rigid enough to prevent laxity in any of these important processes of manufacture. It should make ice cream a safe food for all, but especially for children and for the sick.

Although the primary purpose of a standard for ice cream should be to protect the consumer, it is equally important to make it reasonable for the manufacturer. If the minimum number of bacteria was so placed that it would be impossible to comply with it, it would be disregarded and could not be enforced. It is fair, however, to ask the ice cream manufacturer to use clean products, clean equipment and to control every operation in the manufacture of this important food. Since the bacterial count affords an index to the care used in manufacturing, it makes a good basis for legislative control of the manufacture of ice cream. By the adoption of bacterial standards the manufacturer would be obliged to produce a clean, safe, and healthful food.

From the data given in table 1, it will be seen that half of the manufacturers submitted samples containing less than 100,000 bacteria per gram. From this, it does not seem unreasonable to assume that the other half could do likewise. Assuming these samples to be representative, it would not seem unreasonable from the standpoint of fairness to the manufacturer, to demand ice cream with a bacterial count of less than 100,000 per gram. However, if further investigation shows that ice cream can be produced under careless conditions and still contain fewer than 100,000 bacteria per gram, the figure should be correspondingly lowered. On the other hand, if it is found that ice cream made from clean products and produced under well controlled plant conditions may contain as high as 200,000 or 300,000 bacteria per gram, the standard should be adjusted accordingly.

SUMMARY

The bacteriological analyses of 115 samples of ice cream are submitted. The bacterial counts range from 1500 per gram to 47,000,000 per gram. The average of all the samples is 1,895,000 per gram. However, the average count on a series of samples may not always give a figure that is representative of the whole

class. In this group of variables, the middle class is shown to be a more representative figure than the average.

Three-fourths of the samples contained less than 300,000 bacteria per gram, and half of them less than 100,000 per gram. An analysis of the various factors influencing the bacterial count of ice cream indicates that the effeciency of pasteurization and control of the temperature during the ripening process are the most important factors in producing ice cream with a low bacterial count.

The inhibition of multiplication of the organisms as a result of the low temperature at which the finished product is held, makes the bacterial count of ice cream a good index to the conditions surrounding its production.

The establishment of legal standards governing the bacterial content of ice cream is briefly discussed, but no effort is made to suggest a standard from these results. However, the high per cent of samples containing 100,000 bacteria or less per gram, indicates that this figure would not be unfair to the Kansas producer.

FACTORS INFLUENCING TWO-DAY OFFICIAL BUTTER-FAT TESTS OF COWS[1]

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In official cow testing work the various breed associations base the production of dairy cattle very largely on the records of a two-day test for each month throughout the year. It is important therefore to investigate the factors which may influence the two-day test. A study of these factors shows that some things affecting the test of the cow are under the control of the man in charge of the cow and some things are not under his control. Only a few of these factors can be considered in this paper.

I. FACTORS NOT UNDER CONTROL OF OWNER[2]

1. Seasonal variations. Regardless of all other factors there seems to be a variation in the average test of a cow from month to month. This is shown in table 1.

These figures are based on the averages of two-day Register of Merit Tests of Jersey cows in Tennessee. This table shows that the lowest test for the year is in July with an average of 4.95 per cent and that there is a gradual increase from this to 6.15 per cent for November, the highest month of the year. From November there seems to be a tendency toward a decrease to July. This shows a seasonal variation of 1.23 per cent from July, the lowest month, to November, the highest month. From July to November the increase in test is at the rate of 0.3 per

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[1] Presented at the meeting of the Southern Division, American Dairy Science Association at Memphis, Tennessee, February 6, 1923.

[2] These tabulations were made by H. R. Love, senior student specializing in dairying, University of Tennessee, 1921–1922.

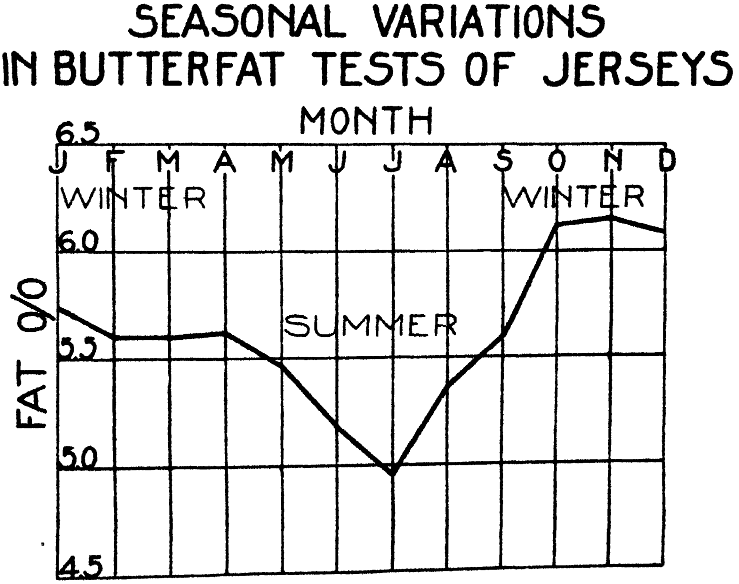
TABLE 1

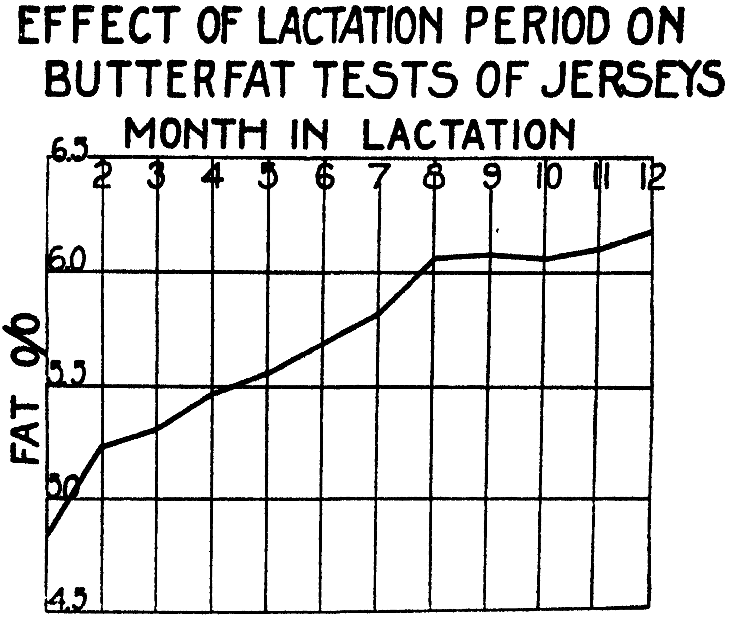
MONTH	NUMBER OF COWS	PERCENTAGE FAT
January	147	5.74
February	284	5.60
March	343	5.60
April	138	5.62
May	137	5.46
June	339	5.18
July	136	4.95
August	347	5.35
September	364	5.59
October	277	6.11
November	137	6.15
December	265	6.08

cent per month. From November to July the decrease it at the average rate of 0.15 per cent per month.

2. Monthly stage of lactation. Independently of all other factors the stage of lactation seems to influence the per cent of butter fat from month to month, as shown in table 2.

These records are based on the two-day Register of Merit records of Jerseys in Tennessee. The lowest test for the year was





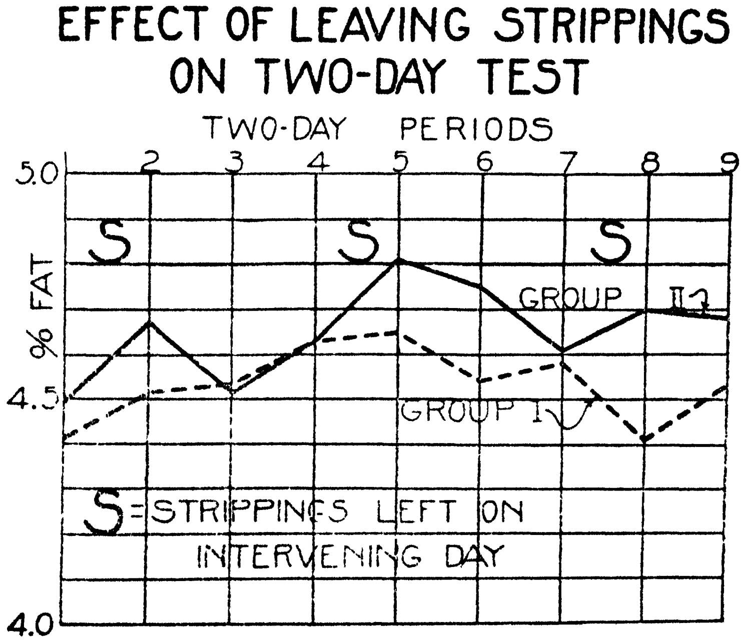
4.84 per cent the first month of lactation. There was a very gradual increase from this to 6.13 per cent the last month of lactation which was the twelfth month. This is an increase of 1.34 per cent from the first to the last month, or an average variation of slightly more than 0.11 per cent per month.

TABLE 2

MONTH	NUMBER OF COWS	PERCENTAGE OF FAT
1	154	4.84
2	154	5.23
3	154	5.31
4	154	5.47
5	154	5.56
6	154	5.69
7	154	5.82
8	154	6.06
9	154	6.08
10	154	6.06
11	151	6.10
12	143	6.18

II. FACTORS UNDER THE CONTROL OF OWNER[3]

1. Effect of leaving strippings in the udder on the following two-day test. Twenty-two cows were used in the experiment which covered a period of twenty-three consecutive days. The cows were divided into two groups of equal number and with an equal number of Jerseys and Holsteins in each group. Group I was used as a check for Group II.



The object of this experiment[3] was to determine the effect on official cow testing records of leaving strippings in the udder. Strippings were left in the udders of all the cows in group II on three different occasions at wide intervals. One-fourth approximately of the normal amount of milk was left as strippings. One whole day intervened between each two-day test period when the strippings were left. The strippings were always left at the

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[3] The laboratory investigations in this experiment were conducted by Ben P. Hazlewood, senior student specializing in dairying, University of Tennessee, 1922–1923.

TABLE 3

Effect of leaving strippings on per cent of butterfat

Stripping trial	FIRST			SECOND				THIRD				
Two-day testing periods	1	Milking	2	3	4	Milking	5	6	7	Milking	8	9
	Average fat		Average fat	Average fat	Average fat		Average fat	Average fat	Average fat		Average fat	Average fat
	per cent		*per cent*	*per cent*	*per cent*		*per cent*	*per cent*	*per cent*		*per cent*	*per cent*
Group I	4.41	Normal	4.51	4.53	4.63	Normal	4.65	4.54	4.58	Normal	4.41	4.53
Group II	4.49	Stripping left	4.67	4.51	4.63	Stripping left	4.81	4.75	4.61	Stripping left	4.70	4.68
Difference	0.08		0.16	0.02	0.00		0.16	0.21	0.03		0.29	0.15
Increase of Group II apparently due to leaving strippings*			0.08				0.16				0.26	

* This figure is obtained by subtracting the difference between the two groups before the stripping period from the difference between the two groups after the strippings are left.

evening milking. The cows were milked twice daily. The experiment started January 3, with p.m. milking and ended January 25 with the a.m. milking. There were fifteen milking periods between the first and second trials on which strippings were left, and thirteen milkings between the second and third trials on which strippings were left.

In considering the effects of leaving strippings in the udder it is necessary to consider the cow as the unit in determining the average per cent of fat for the group. In calculating the average per cent of fat for a group the average is taken of the per cents of fat of the individual cows. This is not the method used in calculating the per cent of fat in the milk of individual cows when the total milk is divided into the total fat for a two-day period. The object of official testing work is to determine the production of individual cows and not the production of a herd or any group of cows. The monthly production is based on the average per cent of fat of the two-day test. The average milk production for the two-day test period is not used in calculating the milk production for the month.

There are so many factors influencing the test of a cow that it is difficult to say that any two-day test period is normal for that particular cow. It is necessary therefore to use as a check on the experiment a group of cows handled normally and compare the records of these with the group in which strippings are left.

RESULTS OF EXPERIMENT

Table 3 shows the effect on the two-day butterfat test of leaving strippings in the udder. In the first trial group II, in which strippings were left, made an average increase in fat of 0.08 per cent over group I, which was milked in a normal manner. In the second trial group II increased 0.16 per cent, and in the third trial 0.26 per cent.

Both groups averaged approximately the same per cent of butterfat for the first two-day test period. Group II increased in average per cent of butterfat more rapidly after strippings were left than group I even though the latter group made a slight increase. At the fourth two-day test period the two groups again tested the same in per cent of butterfat. After strippings were left in the second trial group II made an increase in average per cent of fat of 0.18 while group I made an increase of only 0.02 per cent. The group in which strippings were left increased 0.16 per cent fat more than did the other group. Group II remained high in per cent of butterfat for a period of four days but on the seventh two-day test period the two groups tested approximately the same again. In the third trial group II increased 0.26 per cent more than group I and remained higher for a period of four days.

SUMMARY

A preliminary report of these experiments indicate the following:

1. A great many factors may influence the per cent of fat in cows milk.

2. Both the season of the year and the period of lactation cause a variation in the per cent of butterfat, the highest tests occruring, on the average, in the winter months and the latter months of the lactation period. The lowest tests occur on the average in the summer months and the first month of the lactation period.

3. Leaving one-fourth of the normal amount of milk as strippings in the udder of a cow apparently caused an increase in the per cent of butterfat in the milk of some cows, but the effect seemed to last over several milkings so that a single preliminary milking would not prevent the leaving of strippings at a milking previous to the preliminary milking.

A SCREEN USED IN PHOTOGRAPHING ANIMALS

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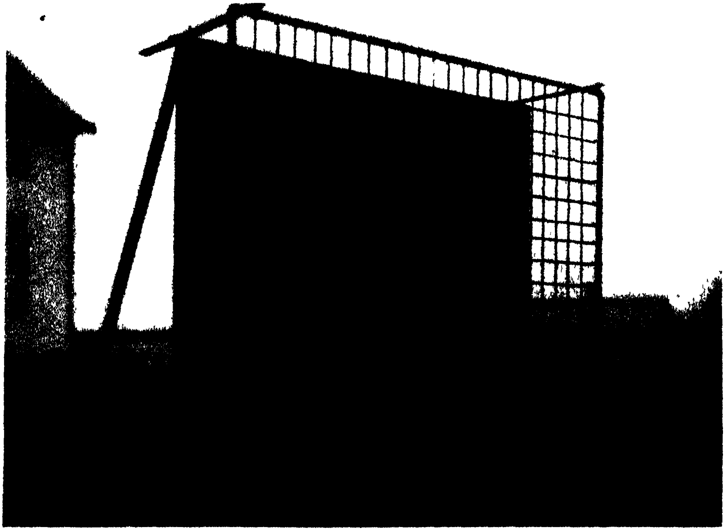
About six years ago the writer planned and constructed the device here described, in which to photograph cattle used in experiments. A considerable number of persons have been interested in it and the suggestion has been made that a description of it be published in some scientific journal. The writer finds it a very convenient piece of apparatus and this description is presented with the hope that it may be of use to others.

The one shown in the cuts consists of a screen, a platform and a background. The screen is constructed as follows: A rectangular frame 9 by 12 feet is made of 2-inch pipe. Holes large enough for a no. 9 wire are drilled through the frame at intervals of 6 inches. Vertical and horizontal wires are passed through these holes and stretched to form a screen with 6 inches mesh. It is important that the sides and ends of the frame be held rigidly while the wires are being stretched and secured. The wires should be brazed or electric welded at most of the points where they cross, in order to prevent their becoming slack and slipping out of place. The writer attempted to solder them but solder does not hold well. The lower horizontal wire should be placed so that the distance from it to the platform on which the frame rests and on which the animal stands shall be just the same as the space between the other wires.

The platform is 4 by 12 feet and consists of planks spiked to 2 by 4 inch pieces, the two end pieces extending about 4 feet to the rear for attaching the braces of the background.

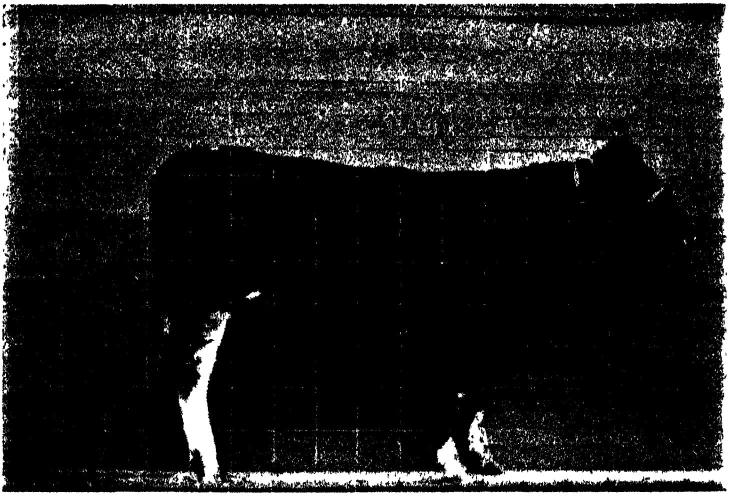
The background should be as long as or longer than the screen. It is erected at the rear of the platform and consists of matched flooring on 2 by 4 inch studding. This would better have a canvas stretched over it as in the photographs the wire lines may be confused with the crevices between the boards.

Two strips are attached to the top of the screen frame and pass back over the top of the background. Holes are bored through these strips at intervals and pins are passed through these holes into holes bored into the top of the background. This permits the shifting of the screen to regulate the space between the screen and the background to suit the size of the animal. Just enough space should be allowed to permit the animal to stand comfortably. If desired, the background may be made movable and the screen fixed. The apparatus is so arranged that a horse may be hitched to it to move it about.



As stated, the mesh of the screen is 6 inches. It would be better to make the spacing according to the metric system. A mesh of 15 cm. would be about right for cattle. The size of the screen and the mesh should be adapted to the size of the animals to be photographed. The same plan could be used for such small animals as rats and guinea-pigs.

In taking photographs the camera is set a definite distance from the screen. It may be raised and lowered according to the size of the animal. If the animal does not happen to stand in the center of the screen the camera may be shifted to the right or left.



If desired, the screen may be placed against the background and the animal taken in front of it. If a wider platform is made and a removable canvas background is used, the front or rear of the animal may be taken.

The writer prefers this method to the one where the lines are painted on the background, for studying comparative size, conformation, location of color markings, extent of color markings, etc. It assists greatly in keeping animals placed while photographs are being taken, resulting in a considerable saving of time and patience. Perhaps, its greatest fault is that it is not well suited to use in direct sunlight on account of the shadows (see figures).

THE PRODUCTION OF VOLATILE FATTY ACIDS AND CARBON DIOXID BY PROPIONIC ACID BACTERIA WITH SPECIAL REFERENCE TO THEIR ACTION IN CHEESE

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INTRODUCTION

Work has been reported elsewhere (4) on the causal factor in the production of eyes and flavor in Emmental or Swiss cheese. The organism used in this work, which has been tentatively designated as Bact. acidi-propionici (d), belongs to the group of propionic-acid-producing bacteria which has been studied by a number of European workers, especially Von Freudenrich and Jensen (2). As has been pointed out, these organisms produce propionic acid, acetic acid, and carbon dioxid from lactose and lactates, the latter supposedly being the source of those compounds in Swiss cheese.

In connection with the cheese-ripening problem it is of interest and importance to know what substances in cheese may serve as sources for carbon dioxid, the production of which is responsible for eye formation, and for volatile acids, especially propionic, which are also probably involved in the development of some of the characteristic properties of cheese of the Emmental type. It is the purpose of the present paper to report some data bearing on this question.

METHODS

In these experiments the media used, with the exception of the tests on pepton alone, consisted of 1 per cent pepton solution with the addition of 2 per cent of the test substance. The organic acids were used in the form of their calcium salts.

The initial reaction of all media was approximately pH 7.0. Incubations were at 30°C.

Volatile fatty acids were determined by the Duclaux method. On the primary steam distillation one liter of distillate was collected from 100 cc. of culture. The neutralized distillate was then evaporated and distilled, according to the original Duclaux method, for the determination of the kinds and proportions of volatile acids present.

In the experiments in which the action of the organism on the volatile acids (formic, acetic, propionic, and butyric) were tested, quantitative and qualitative determinations were made of the volatile acids in the cultures and in sterile media of the same compositions. Any appreciable decomposition of the acid in question should be apparent upon a comparison of the analyses obtained upon the sterile and inoculated media.

Carbon dioxid determinations were made in the special tube designed for this purpose by Eldredge and Rogers (1). Although this method does not give the absolute amount of carbon dioxid produced, since the dissolved gas is not measured, it gives excellent results for comparative purposes. The culture was grown in 30 cc. of the test media and the carbon dioxid produced was absorbed with barium hydroxid. Control tubes containing 1 per cent pepton were also run in each case, and the figures so obtained deducted from the values found with the test substance. Since the organism under consideration produced carbon dioxid quite abundantly from pepton alone, the exact figures obtained from the various test substances are not of great importance. We have reported carbon dioxid production from the test substances, therefore, simply as positive or negative. In the tables in which the amounts of carbon dioxid produced are reported, the results are expressed in terms of the number of cubic centimeter of N/10 $Ba(OH)_2$ neutralized by 30 cc. of culture.

EXPERIMENTAL DATA

The action of the propionic organism, of the type with which we worked, upon the various substances tested is shown in table 1. It should be kept in mind in examining these figures that the products obtained from the different substances are not quantitatively comparable, due to variable incubation periods and other variable conditions. The results given for lactose and glycerol, which were tested without the presence of a neutralizing agent, are obviously not quantitatively comparable with those obtained in the fermentation of compounds which did not give rise to an increase in hydrogen-ion concentration.

TABLE 1

Action on various compounds

SUBSTANCE	INCUBATION TIME	FERMENTATION	CARBON DIOXID	VOLATILE ACIDS			
				N/20 per 100 cc. of culture			Ratio P:A
				Total	Propionic	Acetic	
	days			*cc.*	*cc.*	*cc.*	
Lactose	30	+	+	99	64	35	1.8
Lactic acid	60	+	+	205	139	66	2.1
Succinic acid	60	+	+	72	42	30	1.4
Formic acid	18	–	–				
Acetic acid	30	–	–				
Propionic acid	60	–	–				
n-Butyric acid	50	–	–				
Iso-butyric acid	50	–	–				
Glycerol	40	+	+	68	46	22	2.1
Butterfat	30	+	+	22	13	9	1.4
Pepton (1 per cent)	30	+	+	10	–	–	–
Pepton (4 per cent)	40	+	+	48	13	35	0.4

From the standpoint of cheese ripening the fermentation of lactose by this organism is probably of little significance, since the sugar in cheese is consumed before the development of eyes and flavor begins. From another point of view we have studied the propionic-acid fermentation of lactose in considerable detail and the material thus collected will be presented elsewhere.

As stated earlier in this paper the fermentation of lactic acid by the propionic organisms is well known and hence needs no especial comment. As may be seen from table 1, however, the lactates of cheese do not constitute the only possible source of carbon dioxid and volatile acids.

The fermentation of succinic acid is of considerable interest since the occurrence of this acid in cheese is well established. If the succinic acid of cheese results mainly from the primary lactose fermentation, as the results of Jensen (3) and of Suzuki, Hastings and Hart (6) would indicate, the presence of succinates at the time the propionic organisms begin their work would seem to be assured. It has been noted elsewhere (4) that this organism differs in some of its characteristics from the published descriptions of the propionic bacteria of Von Freudenrich and Jensen (2). Its action on succinic acid would appear to further justify its designation as a new variety.

The extent to which glycerol may be liberated in ripening cheese is problematical. Although no very extensive decomposition of fat is known to take place in Swiss cheese, it would appear likely that some hydrolysis of fat might result from the complex biological and chemical changes which take place.

Of particular interest is the apparent decomposition of butterfat by the propionic organism. In this connection, however, the possibility of error should be kept in mind. In testing the fat, the volatile fatty acid production was checked by the growth of the organism in the same pepton concentration without the presence of fat. The difference, though small, was constant in the duplicate sample tested. A repetition of the experiment again indicated a decomposition of the fat to about the same extent. While tests of the sterilized fat-pepton medium gave no indication of decomposition upon autoclaving, as revealed by the determination of volatile acids, we must still admit this possibility; and since the organism with which we are dealing ferments glycerol with the formation of the same products, it is possible that the propionic and acetic acids found were the result of a glycerol fermentation of the hydrolyzed portions of the fat.

Should the decomposition of fat by this organism become definitely established, the significance of that fact in the ripening of cheese would be obvious. Even a slight cleavage of fat would probably have a profound influence upon the resulting flavor of the cheese. It is not at all unlikely, moreover, that the characteristic whitish color which develops in Swiss cheese during the ripening process may be due in part to changes in the milk fat.

So far as could be detected by the methods employed, the volatile acids (formic, acetic, propionic, and normal and isobutyric) are not decomposed by this type of propionic organism. In the case of acetic acid the visible growth of the organism appeared to be stimulated somewhat in comparison with its growth in the pepton solution alone; but so far as could be determined analytically there was little if any decomposition of the acetate, nor did the presence of acetate measurably stimulate carbon dioxid production. Determination of the action on acetic acid was complicated by the fact that some acetic acid was simultaneously produced from the pepton contained in the test medium. But even so, an appreciable destruction of the acetate should have been detected.

TABLE 2

Carbon dioxid and volatile acids from pepton

CONCENTRATION OF PEPTON	CARBON DIOXID	VOLATILE ACIDS			
		N/20 per 100 cc of culture			Ratio P A
		Total	Propionic	Acetic	
per cent		*cc*	*cc*	*cc*	
1	5.1	13.0			
2	10.3	20.2	4.6	15.6	0.3
4	14.9	43.4	13.4	30.0	0.5
8	23.4	82.0	43.6	38.4	1.1

From the results obtained on pepton alone it is apparent that some of the nitrogenous constituents of cheese may also serve as sources of carbon dioxid and volatile acids when acted upon by this organism. This is more clearly brought out by the experiment reported in table 2, in which measurements were made of the carbon dioxid and volatile acids produced in pepton solutions of different concentrations.

Since bacteriologic peptones are made partly at least from meat it is obvious that they should contain a little lactic acid. Dr. Rupp of these laboratories has examined a number of samples of commercial peptones for lactic acid and has found this acid, though constantly present, occurs in amounts too small to account for all of the volatile acids produced by this organism from pepton.

Many possibilities suggest themselves in explanation of the propionic and acetic acid production from nitrogenous compounds. For examples, glutanic and aspartic acids may yield succinic acid, which was shown to be fermented by the propionic organism. A number of amino acids, as for example alanin, may yield lactic acid and hence serve as sources of the volatile acids. We did not have at hand an adequate supply of pure amino acids to undertake a systematic study of this phase of the subject, but we will report here a suggestive result obtained with aspartic acid.

TABLE 3

Influence of aspartic acid on carbon dioxid and volatile acid production

MEDIUM	INCUBATION PERIOD	CARBON DIOXID	VOLATILE ACIDS			
			N/20 per 100 cc. of culture			Ratio P:A
			Total	Propionic	Acetic	
	weeks		*cc.*	*cc.*	*cc.*	
4 per cent pepton	5	24	51	18	33	0.55
4 per cent pepton 0.5 per cent Na. Aspariginate	5	31	60	18	42	0.43
4 per cent pepton	10		61	17	44	0.39
4 per cent pepton, 0.5 per cent Na. Aspariginate	10		83	18	65	0.28

A 4 per cent pepton solution to which was added 0.5 per cent sodium aspariginate was tested, along with a 4 per cent pepton solution as a control, for carbon dioxid and volatile acid production. As indicated by table 3, aspartic acid is probable one of the sources of these products among the nitrogenous constituents of cheese. However, it apparently yields acetic but not propionic acid.

In considering the data presented in this paper on the action of Bact. acidi-propionici (*d*) upon various substances, it is important from the standpoint of cheese ripening to bear in mind the effect upon this organism of the associated growth of other bacteria. As has been shown elsewhere (5), the propionic fermentation of lactose and lactates may be greatly accelerated by the presence of certain other organisms. If the same phenomenon takes place in the fermentation of other substances, it is not unlikely that the action of the propionic organism is much greater on some of these compounds in cheese than would be expected from the results herein obtained in pure culture studies.

SUMMARY

Observations are recorded concerning the action of Bact. acidipropionici (*d*), the causal factor in the production of eyes and the characteristic sweetish flavor of Swiss cheese, upon various substances which occur in cheese.

Aside from its previously known action upon lactose and lactates, it has been found that this organism can produce carbon dioxid, propionic acid and acetic acid from succinates, glycerol, nitrogenous compounds (pepton), and perhaps to a slight degree, from butterfat.

From pepton the proportion of acetic acid to propionic acid produced was greater than in the cases of the other substances acted upon. Aspartic acid was shown to be able to serve as a source of acetic acid and carbon dioxid.

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III. SODIUM HYPOCHLORITE

THE RATE OF DECOMPOSITION OF SODIUM HYPOCHLORITE IN COW'S MILK

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Hypochlorites are very rapidly decomposed by most organic complexes. Leastwise, raw vegetable and animal extracts absorb the available chlorine spontaneously. Chlorine in the form of its gas, as nitrogen tri-chloride, as chloramines, or as hypochlorites has been considerably exploited as a sterilizing or preserving agent for food products. In view of the severe chlorinating and oxidizing properties of hypochlorites it is very doubtful if they exert any marked selective disinfectant action when conducted into raw mixed food products such as oysters, canned vegetables, meats, milk, etc. In order to exert a preserving power in such substances, the chlorine would necessarily be required to attack the enzymes and microörganisms initially, and only moderately the food products themselves. Practically no work has been published to illustrate any such selective action. It is conceivable that selective might be possible. For instance (*a*) reductases, and (*b*) anaerobic organisms (or their products) might be believed to absorb the chlorine at the greatest rate and hence constitute cases of direct selection. While this is a rather beautiful hypothesis it has not, to my knowledge, been subjected to close scrutiny. It is not the purpose of this paper to specifically attack the problem, but certain results obtained in these studies have shed a few rays of light on instance (*a*) and they will be reported at this time. The second instance (*b*) has been investigated in a manner of attack which is outside the scope of this paper and will be presented at another time.

There is another phase of hypochlorite disinfection more pertinent to the immediate need, and in the data submitted herewith it will be shown that sodium hypochlorite disappears as such very rapidly in the presence of fresh and pasteurized cow's milk up to the zone of saturation, after which it is absorbed but slowly. The treatment of dairy and other food product utensils with chlorine solutions is a matter of growing interest. End-points in this practice are given scarce concern, so that the operator seldom knows whether enough or too much of the disinfectant is used. There is no chemical or biological data available on what happens to sodium hypochlorite when it comes into contact with milk. Does it exist in milk as such after being added? How much will milk absorb and how fast does milk absorb it at different temperatures? These questions are live biological problems, and it is to help answer them that this and similar work was undertaken

SCOPE AND METHODS OF STUDY

Fresh milk from the dairy was secured which represented a composite from several herds and consisted of both evening's and morning's milking. A portion was kept fresh by packing in ice, a second portion was boiled at 100.2°C. for two minutes, while a third portion was skimmed in the fresh state and then held in ice.

This milk was then subjected to the following study:

1. The Schardinger enzyme test or reductase reaction was applied to each of the three milks to determine the presence of the reductase or reducing bodies in the fresh samples and its absence from the boiled sample.
2. Measured quantities of sodium hypochlorite of standard strength were immediately added to definite quantities of each milk held to constant temperature in a thermostat and the rate of its disappearance determined with sodium iodide solution and starch paste.
3. The rate of absorption of available chlorine from sodium hypochlorite by the fresh skimmed milk was then determined throughout the temperature range of 20° to 70°C.
4. The rate of absorption of available chlorine from sodium hypochlorite by fresh sodium caseinate was then measured at one

temperature (40°C.) in a manner similar to that adopted in "2." The idea was to show that the protein molecule of casein may be the leading agent in milk to decompose the hypochlorites.

5. The hydrogen ion concentration of the sodium hypochlorite treated milk was measured in all cases, to determine the effect of the dilute hypochlorite on the reaction of the milk. This was measured electrometrically with an ionometer cell.

PREPARATION OF THE SODIUM HYPOCHLORITE

In the main the method described in "I. Sodium hypochlorite" (1) was followed, but it will be briefly recounted here. Chlorine from a drum was passed through a flow meter into a solution mixture of 7.5 per cent of NaOH (50 per cent caustic soda) and 2.5 per cent of Na_3CO_3 (anhydrous) until a concentration of 3.25 per cent available chlorine was reached. The chlorination was conducted at room temperature (27°C.) and without any precautions as to the screening from day or sun light. The chlorinated solution was pink to cresol phthalein and blue to thymol phthalein (flash method) but was not pink to powdered phenol phthalein. The hydrogen ion concentration was roughly at pH 10.0. This stock solution of sodium hypochlorite was further diluted to exactly a 1 per cent solution of available chlorine as needed for the above studies.

THE SODIUM IODIDE-STARCH TEST FOR FREE SODIUM HYPOCHLORITE

This test is sensitive to 1 part of sodium hypochlorite in 1,500,000 parts of water when viewed against a white background. Five grams of sodium iodide are added to 100 cc. of a 1 per cent solution of soluble starch. Two-tenths cubic centimeter of this mixture is added to 1 drop of acetic acid held in the depression of a porcelain test-plate. A drop of the milk or other mixture which is to be tested for sodium hypochlorite is placed on the acid-sodium iodide starch mixture and the whole is stirred with a fine platinum wire. A deep blue color denotes much, a purplish considerable, and a faint red-violet a trace of sodium hypochlorite. The color develops immediately.

It should be said here that the test for free hypochlorite needs qualification, because the misapprehension on the part of some as to just what is meant by the test. The starch iodide test has been used extensively to determine the presence of certain oxidizing agents. Starch is used to indicate free iodine. Generally very little thought is given to the reaction of the solution in which the test occurs, except of course to have it sufficiently acid so that the starch-iodine complex will be blue. If the solution is alkaline (above pH 11.0) the blue complex becomes colorless. Now in the test under our consideration we are depending upon the available chlorine in the sodium hypochlorite to set the iodine free and hence form the blue complex. In reality it would not be necessary to add the acetic acid, since the milk itself containing the added hypochlorite is sufficiently on the acid side (pH 6.5 to 7.0) to furnish the correct conditions for the development of the blue color. In fact, a large number of experiments were made without the addition of any acid and substantially the same results were obtained. Under the conditions of the chlorination studied we wish to measure the decomposition of the sodium hypochlorite and not the *iodine-freeing capacity of the chlorinated compounds in the milk.* Whenever any free sodium hypochlorite is present at the reaction of milk it forms a blue compound with starch. A trace of sodium hypochlorite added to milk fails to give a color at all with starch-sodium iodide. A large quantity added to milk gives a blue color. Now, if we add some strong acid (HCl) to the milk containing the trace of sodium hypochlorite we will get a bluish violet coloration with the starch iodide. It is evident that in this latter case we have the product or products of the chlorination furnishing sufficient of some oxidizing substance in the presence of the strong acid to cause the liberation of a trace of iodine. But it would be an error to interpret this as coming directly from sodium hypochlorite. The question can be settled in another manner. If we determine the hydrogen ion concentration of milk to which a trace of sodium hypochlorite has been added we get a very constant potential in a short time at the hydrogen electrode of a calomel halfcell set-up. This is not true if there is any free sodium hypochlorite present. When hypochlorite is present around the hydrogen electrode (palladiumized platinum) the potential is always very unsteady owing to rapid reduction of the hypochlorite by the nascent hydrogen with the subsequent production of acid products.

The writer holds, therefore, that the work of Rupp (2) recently reported is in error in that Rupp proposed a test to show the presence of hypochlorites and chloramines in milk, whereas these compounds in the concentration added to the milk by Rupp were very likely absorbed in a short time under his working conditions. Any free hypochlorite or *available chlorine* compound present in milk could be determined by merely adding starch-sodium iodide paste, whence a bluish color would result. The substance of Rupp's work is sound, but we believe the statement of the title is misleading, and it is to this that the writer alludes in the preceding argument.

MEASUREMENT OF THE pH OF THE MILK

The electrometric determination of the hydrogen ion concentration of solutions of sodium hypochlorite with a hydrogen electrode is very difficult. It is possible to measure it in very dilute solutions by simply waiting for the catalytic reduction, at the hydrogen electrode, of the contained hypochlorite to equilibriate. This method is not very accurate except in strongly buffered solutions such as milk; even here the small amount of acid reduction products formed from the hypochlorite gives a slightly higher resulting hydrogen ion concentration than actually exists in the presence of the unreduced sodium hypochlorite. Another method of obtaining a fairly steady potential in a dilute hypochlorite solution is to use a flowing hydrogen electrode. This has partially been accomplished by W. A. Noyes (4) in measuring the dissociation of hypochlorous acid with a platinized electrode. It has not been reported before in connection with hydrogen ion measurements in hypochlorite solutions. The principal idea in this method is to provide the platinized or palladiumized electrode with a constantly fresh supply of the *hydrogen-saturated* sodium hypochlorite solution being measured, during the reading of the potentials, in order to reduce the electrode catalysis to a minimum. Some measurements made in this manner have furnished very good results.

The pH of the *concentrated* hypochlorite solutions were determined colorimetrically, following the suggestions of Cullen (5) but introducing thymolphthalein as a valuable aid in gauging the stable point. The stability of these concentrated solutions of sodium hypochlorite has been mentioned in other connections (1), but it will do no harm to restate that they will remain stable even in the presence of sunlight for several weeks without appreciable loss of available chlorine providing the hydrogen ion concentration is controlled to the proper point during their preparation, viz., pH 10.0 to 10.5.

1. The reductase reaction of the milk samples

Both the Schardinger reaction[1] and the methylene blue reduction test[2] were applied to the three samples of milk.

These tests reacted positively for reducing substances in the raw whole milk and raw skimmed milk. The Schardinger reaction showed complete reduction in the whole milk in thirty minutes, and in the skimmed milk after seventy minutes. The methylene blue reduction test showed complete reduction of methylene blue in the whole milk after two hours, and in the skimmed milk after two and one-half hours.

The boiled milk showed no reduction with either test after a period of ten hours contact.

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[1] The Schardinger reaction seems to depend upon the action of some substance (aldehydase) present in milk which is activated by formaldehyde to rapid reduction of methylene blue. It is applied as follows: 5 cc. of a saturated alcoholic solution of methylene blue and 5 cc. of formalin are diluted to 200 cc. with water; 1 cc. of this reagent is added to 20 cc. of milk held at 45°C. in a water bath. Decolorization of the methylene blue shows presence of Schardinger's reductase.

[2] The principle of this reaction is the reduction of methylene blue to methylene white by reducing substances either present in the milk or produced there by microörganisms. It is applied by adding an aqueous solution of medicinal methylene blue to 10 cc. of milk so that the resulting concentration of methylene blue is about 1 to 200,000. The milk is incubated at 37°C.

It was clearly established that there were present in the raw milk reducing substances for the NaOCl to oxidize, while the boiled milk contained a minimum of these.

Precautions were taken to prevent bacterial contamination of the boiled milk previous to making the chlorination tests.

2. Rate of chlorination of raw whole milk, boiled milk and raw skimmed milk

The method of treatment of each type of milk was exactly the same.

One hundred-cubic centimeter portions were placed in Erlenmeyer flasks which in turn were set on the shelf of a circulating water thermostat controlled to a temperature of 30°C. ± 0.2°C.

When they had reached the temperature of the bath the following quantities of sodium hypochlorite (1 per cent available Cl_2) solution were added respectively to each flask of milk. A drop of milk was withdrawn at intervals and tested on the porcelain tile, previously described, for the presence of free sodium hypochlorite. The nearest tenth of one minute when the faint red-violet of the starch-sodium iodide reaction failed to appear was taken as the time required for the respective quantities of available chlorine to become absorbed by the milk in question. Several sets were run to eliminate errors in checking the time factors. When a sample showed complete loss of free sodium hypochlorite it was immediately removed from the bath and set in snow-water to await pH measurement.

The whole milk had a fat content of 3.8 per cent while the skimmed milk contained 0.02 per cent.

In table 1 will be found the average results for the (*a*) raw whole milk, (*b*) heated whole milk, and (*c*) raw skimmed milk.

3. Influence of temperature on the rate of chlorination of milk by NaOCl

Six portions of the raw skimmed milk (*c*) of 100 cc. each were set in their respective water baths heated and controlled to the respective temperatures 20°, 25°, 30°, 40°, 60° and 70°C. Into each portion was stirred exactly 10 cc. of 0.1 per cent available chlorine solution (0.21 per cent NaOCl solution). At short time intervals a drop of each solution was withdrawn and tested on the porcelain test plate for free NaOCl. The times of first disappearance of free NaOCl from these solutions at the temperatures in question are found in table 2.

TABLE 1

QUANTITY OF MILK	QUANTITY OF NaOCl	Cl_2	RATE OF CHLORINATION			ELECTROMETRIC pH (25°C		
			Raw milk (a)	Heated milk (b)	Skimmed milk (c)	(a)	(b)	(c)
cc	*cc*	*mgms*	*minutes*	*minutes*	*minutes*			
100	None°	None	None	None	None	6.64	6.51	6.62
100	0.5	5	0.15	0.15	0.2			6.65
100	1.0	10	0.85	0.85	0.9			6.69
100	1.5	15	3.75	4.00	4.1			6.72
100	2.0	20	18.5	16.75	17.5			6.85
100	2.5	25	50.0	52.0	55.0			6.91
100	5.0	50	Free NaOCl after four hours					

TABLE 2

MILK	NaOCl	AVAILABLE CHLORINE	TEMPERATURE OF SOLUTION	TIME OF CHLORINATION
cc	*cc*	*mgm.*	°C	*minutes*
100	10	10	70	0.8
100	10	10	60	1.5
100	10	10	40	4.5
100	10	10	30	10.5
100	10	10	25	18.5
100	10	10	20	21.5

4. Chlorination of sodium caseinate by NaOCl

A 4.5 per cent solution of sodium caseinate was prepared from pure casein made according to Hammarsten and purified according to Robertson (3). The solution was adjusted to pH 6.5. One hundred-cubic centimeter portions were set in the water bath controlled at 40°C. Sodium hypochlorite of the concentration in "2" was added to the sodium caseinate in the quantities indicated in table 3. The time for disappearance of the free NaOCl was measured.

TABLE 3

Chlorination of sodium caseinate by NaOCl; pH 6.5 (4.5 per cent solution)

SODIUM CASEINATE SOLUTION	NaOCl SOLUTION	AVAILABLE Cl_2	TEMPERATURE OF CHLORINATION	TIME OF CHLORINATION
cc	*cc*	*mgm*	°*C*	*minutes*
100	1.0	10	40	0.4
100	1.5	15	40	1.2
100	2.0	20	40	2.75
100	2.5	25	40	5.5
100	3.0	30	40	9.0
100	5.0	50	40	20.5

CONCLUSIONS

1. A comparison of the relative time intervals (table 1) for the chlorination of the raw whole, boiled whole and raw skimmed milk, reveals that there is apparently no selective action on sodium hypochlorite by bodies present in the milk which effected the rate of chlorination. Although the boiled milk showed no reduction of methylene blue in either the Schardinger or methylene blue reduction test, it reduced NaOCl with the same speed as the milk which rapidly decolorized methylene blue. If such selective action exists the present test is too clumsy to reveal it.

2. The absorption of chlorine from the hypochlorite is very rapid at first, and as the milk becomes saturated its rate falls off. The presence of 3.8 per cent butter fat does not influence the rate, from which we can assume that the other substances present in the milk are more easily attacked by the NaOCl. The milk seemingly became quite saturated with available chlorine when 100 cc. of milk reacts with 50 mgm. in the form of 55 mgm. of free sodium hypochlorite, or 5 parts in 10,000. This concentration is too small because the 50 mgm. actually show no free NaOCl after five hours at 30°C.

3. Sodium caseinate, freshly prepared from pure NaOH and casein, absorbs available Cl_2 from NaOCl with great rapidity. The protein content of caseinate solution was approximately the same as that in ordinary milk. In preparing the caseinate solution care was taken to avoid alkaline hydrolysis by adding the NaOH to the soaked casein in quantities which held the

hydrogen ion concentration below pH 8.2. The possible influence of the SH groups in the casein molecule is suggested as partially responsible for the rapid absorption of Cl_2. We can believe that much of the chlorine absorbing power of milk is due to the proteins and nitrogenous bodies contained in it.

4. The temperature markedly influences the destruction of NaOCl by milk. This is also true of other types of chlorination reactions. Raising the temperature from 20° to 60°C. decreases the time of chlorination to one-fifteenth of that required at 20°C. This is an important fact to remember in connection with food preserving measures and disinfection of milking machines by sodium hypochlorite.

5. The change in pH of the milk due to the added NaOCl solution did not increase the alkalinity sufficiently to have an appreciable effect upon the speed of chlorination. This point was checked in another manner by rendering the milk slightly alkaline at the start and adding like quantities of NaOCl. Like velocities of chlorination were obtained in each case.

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SOME DETERMINATIONS ON THE SOLUBLE NITROGEN COMPOUNDS OF CREAM AND BUTTER

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In the manufacture of butter, some of the non-fatty constituents of the cream are held in with the fat and become a part of the finished product. The object of this study was to find to what extent certain of these products would be found in butter made from samples of cream varying in age and quality and whether there was a difference in the fresh butter and in their keeping qualities.

Marshal (1) found that the per cent of the total nitrogen in butter not precipitated by phosphotungstic acid, was slightly greater on fresh butter that scored low, than on butter with a higher score, and that the lower scoring butter had the largest increase of soluble nitrogen after being held in storage seven to eight months.

M. E. Pennington (2) states that milk kept in cold storage for two weeks showed pronounced proteolysis, by the single or combined actions of bacteria and enzymes, converting the proteins through caseoses and peptones to amino acids.

Brown (3) reports the per cent of total nitrogen not precipitated by copper sulphate about the same in pasteurized cream butter and in raw cream butter, while the action of typical butter organisms, which were inoculated into milk, was to increase the amount of soluble nitrogen.

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[1] The results given in table 1 were obtained by George W. Spitzer and Willis H. Cole, under the general direction of Dr. H. W. Redfield, and acknowledgment is hereby made. Appreciation is also expressed to W. R. North for preparation of the samples made at Grove City; to Mr. L. Jones, Miss D. B. Scott, and Mr. J. I. Palmore, for assistance in making chemical analyses; to the Nitrogen Laboratory for all determinations of total nitrogen, and to Dr. I. K. Phelps, Chemist in Charge of the Food Control Laboratory, for general direction and supervision.

The results reported in this work were on the same samples on which volatile acids and oxidizability value were determined, as shown in the paper entitled "The volatile acids and volatile oxidizable substances of cream and experimental butter" (4). For further information on these samples, reference is also made to the work by North and Reddish (5).

The procedure used in obtaining the results reported in table 1 is as follows:

PROCEDURE FOR CREAM

Two hundred grams of cream were weighed in a 500-cc. wide-mouthed bottle, 4 grams of sodium carbonate, dissolved in a little water, added, and the mixture aerated for six hours into N/10 HCl. The excess acid was titrated and the difference expressed as ammonia. After aeration, the fat was removed from the cream by shaking with gasoline, centrifuging and syphoning off the clear solution. The residue was diluted to 500 cc. and aliquots taken for determination of amino nitrogen and nitrogen not precipitated by phosphotungstic acid as follows: To 25 cc. of the above, representing 10 grams of the original cream, were added 10 cc. of 5 per cent sulphuric acid and 10cc. of a 5 per cent solution of phosphotungstic acid in 5 per cent sulphuric acid and the mixture set aside for fourteen hours. The solution was then filtered and the precipitate washed with 2.5 per cent phosphotungstic acid in 2.5 per cent sulphuric acid until the filtrate and washings measured approximately 100 cc. The nitrogen was determined in this filtrate by the Kjeldahl method. For determination of amino acids, a 50-cc. aliquot of the ammonia free cream was heated to 40° and the casein precipitated by adding a solution of 5 per cent sodium sulphate in 5 per cent acetic acid until slightly acid to methyl red. The mixture was set aside for sixteen hours, filtered, and the precipitate washed with water until the filtrate and washings measured approximately 200 cc. The solution was evaporated on the steam bath to 15 cc., filtered, and the precipitate washed with small amounts of water until the filtrate measured 20 cc. Five-cubic centimeter aliquots of this solution were used for determination of amino acids with Van Slyke's apparatus.

TABLE 1

Showing results on cream and butter made at Denver, 1918

CREAM NUMBER	BUTTER NUMBER	PER CENT OF TOTAL NITROGEN AS								SCORE OF BUTTER		
		Amino nitrogen and Ammonia				Nitrogen not precipitated by phosphotungstic acid						
		Cream	Butter			Cream	Butter					
			Fresh	Cold storage one month	Ice box one month		Fresh	Cold storage one month	Ice box one month	Fresh	Cold storage one month	Ice box one month
15		1.2				7.9						
16		1.6				9.8						
27	B8	2.1	2.5	3.1	3.2	11.2	6.4	9.0	8.3	85	83	82
30		2.3				10.0						
23	B6	2.5	1.1	1.7	2.1	7.7	3.3	3.3	3.0	93	86	86
8		2.7				11.8						
24		2.9				10.5						
14	B1	3.0	1.6	1.8	2.1	8.0	5.3	4.4	6.2	92	90	87
31		3.0				5.3						
4		3.2				6.9						
6		3.2				10.1						
18		3.3				9.5						
20		3.4				9.8						
25	B7	3.4	2.3	2.9	4.3	8.1	3.3	4.9	5.5	90.5	89	85
7		3.5				9.5						
29		3.5				11.3						
5		3.6				7.1						
1		3.7				5.2						
13		3.9				11.6						
17	B3	4.1	2.5	2.8	4.3	9.2	6.5	4.3	6.3	90	89	86
26		4.1				7.9						
28		4.1				10.7						
34		4.2				7.4						
19		4.3				7.9						
10		5.1				8.3						
32		5.1				6.9						
3		5.2				7.6						
21	B4	5.6	1.4	1.4	1.7	4.9	2.3	4.3	3.8	90.5	87	85
33		5.8				8.7						
22	B5	5.9	3.1	3.4	4.0	9.7	5.1	6.7	5.6	87	86	86
12		6.2				9.3						
2		6.8				11.4						
9		8.6				9.8						
11		11.4				16.5						
	B2		2.3	2.5	3.0		5.1	6.5	5.1	91	90	86
	B10		1.7	2.2	2.3		5.2	7.8	6.2	88	86	85
	B9		1.6				2.5			86		

PROCEDURE FOR BUTTER

Six hundred grams of butter were weighed in a quart jar, melted at about 50° and the fat partly syphoned off and the remainder removed with gasoline. The residue was made alkaline with sodium carbonate and aerated, diluted to 300 cc. and aliquots taken for determination of amino nitrogen and nitrogen not precipitated by phosphotungstic acid as in the procedure for cream.

The results on the samples from Grove City, table 2 and following, were obtained by modifying the above procedure as follows: The fat was removed from 100 grams of butter as described in the procedure for detection of neutralizers by Ferris (6). To the fat free residue, 5 cc. of 10 per cent acetic acid and 30 cc. of a saturated solution of picric acid were added, the mixture shaken and filtered. The amino nitrogen and ammonia were determined in 10 cc. of the filtrate by the Van Slyke apparatus and the results calculated to per cent of total nitrogen.

For the determination of the nitrogen not precipitated by phosphotungstic acid, the fat was removed as above and 30 cc. of 3 per cent sulphuric acid and 10 cc. of 5 per cent phosphotungstic acid in 5 per cent sulphuric acid added. The mixture was shaken, allowed to stand a few hours, or over night, filtered, and the nitrogen determined in an aliquot by the Kjeldahl method.

The total nitrogen in butter was determined on the curd which was removed from the fat according to the procedure for fat in butter by Shaw (7).

The results in table 1 show that there is a smaller percentage of the nitrogen present as amino acid and ammonia and as nitrogen not precipitated by phosphotungstic acid in the butter than in the corresponding cream, and, in general, higher results were obtained on cream and butter with the lower score. It is also noticeable that there are higher results for amino nitrogen and ammonia in the butters after being kept in cold storage one month and still higher results on the portions of the samples kept in the ice box at 15° for one month, the increase being correlated in each case with a decrease in score.

For comparison of results on cream and the corresponding buttermilk and butter, a lot of cream was divided into four portions, held under the time and conditions noted in table 2. There is a close agreement of results on the cream and buttermilk, while in two of the cases the per cent of total nitrogen as amino nitrogen is somewhat lower on the butter than on the corresponding cream and buttermilk.

Table 3 shows the amino nitrogen and nitrogen not precipitated by phosphotungstic acid on some high grade sweet cream butters and some low acid cream experimental butters upon which other determinations have been reported elsewhere (8). The results on the experimental butters are slightly higher than on the sweet cream butters, both determinations showing larger amounts of soluble nitrogen after the two periods of storage; five to six months at 22°F and six to seven months at 22°F and then two weeks in the ice box at about 50°F.

TABLE 2

Showing amino nitrogen on cream, buttermilk and butter made at Grove City, 1920

SAMPLE NUMBER	CREAM			AMINO NITROGEN AS PER CENT OF TOTAL NITROGEN		
	Inoculated with	Time held *days*	Temperature	Cream	Buttermilk	Butter
			°C.			
232 C1		3	30–35	4.9	4.4	4.1
232 C2	Bulgaricus	3	30–35	4.3	4.5	4.3
232 C3		4	30–35	5.4	5.3	3.5
232 C4	Peptonizing aerobes	4	30–35	5.9	5.6	3.2

The results in table 4 on partially neutralized clean acid cream butter show results similar to those on the experimental butters given in table 3 from cream slightly acid but not neutralized.

Table 5 gives the results on some experimental butters made from cream treated in various ways. Sample 230 B1 was made from pasteurized cream inoculated with pure oidium lactis starter and held two days at room temperature, and 231 B1 from raw cream inoculated with oidium lactis starter and held twenty-four hours. Samples 236 B1, 236 B2, and 236 B3 were made from the same lot of cream held at 20 to 35° for nine days.

TABLE 3

Showing results on regular run sweet cream butter and on butter from cream slightly soured, Grove City, 1920

NUMBER	ACIDITY OF CREAM	SCORE OF BUTTER			PER CENT OF TOTAL NITROGEN AS:					
					Amino nitrogen			Nitrogen soluble in phosphotungstic acid		
		Fresh	Storage	Ice box	Fresh	Storage	Ice box	Fresh	Storage	Ice box
200 B	0.17	93	94	92	1.4	1.9	1.4	3.0	3.4	3.7
201 B	0.16	94	93½	91½	2.3	1.8	2.0	3.7	5.3	4.6
202 B	0.16	94	92	92½	1.8	1.8	2.0	2.4	4.6	3.0
203 B	0.16	94	93	92	1.8	1.6	1.9	3.2	3.9	2.9
204 B	0.17	94	93		1.4	1.3		2.7	3.7	
205 B	0.17	94	93	91	1.5	0.9	1.4	2.6	3.8	3.7
205 B1	0.40	94	91		1.5	1.2		2.1	7.1	
206 B	0.16	94	92	88	1.2	1.8	1.3	2.7	3.9	3.2
207 B	0.16	94	93	88	1.6	1.5	1.5	2.3	4.7	2.4
207 B1	0.24	94	91½		2.1	2.9		3.9	9.5	
208 B	0.16	94	93	89	1.5	1.9	3.0	2.0	3.2	4.1
208 B1	0.25	93	93	86	2.5	2.3	3.3	3.9	5.0	5.2
210 B	0.16	94	93	93	1.1	1.5	1.6	2.9	3.8	2.3
210 B1	0.29	94	93	90	2.6	2.5	3.8	3.9	5.8	6.2
211 B	0.17	94	93		1.3	1.5		3.0	3.2	
211 B1	0.23	93	93		2.1	1.8		3.3	3.5	
213 B	0.15	94	93		0.9	1.4		1.8	3.1	
213 B1	0.31	94	93	88	1.7	2.0	4.1	3.0	3.2	6.6
214 B	0.16	94	93		1.0	1.0		2.6	3.2	
214 B1	0.30	94	93	91	2.0	1.7	2.0	3.4	4.3	4.1
215 B	0.17	94	92½	91	1.1	1.3	1.7	2.4	3.3	2.3
215 B1	0.27	93	92		1.3	1.7		2.7	3.7	
Sweet cream butter "B"										
Maximum					2.3	1.9	3.0	3.7	5.3	4.6
Minimum					0.9	0.9	1.3	1.8	3.1	2.3
Mean					1.4	1.5	1.8	2.7	3.8	3.2
Experimental butters "B1"										
Maximum					2.6	2.9	4.1	3.9	7.1	6.6
Minimum					1.3	1.2	2.0	2.1	3.2	4.1
Mean					2.0	2.0	3.3	3.3	5.3	5.5

Sample 236 B1 was made from raw cream, 236 B2 from pasteurized cream inoculated with pure oidium lactis starter, and 236 B3 from pasteurized cream inoculated with B. lactis acidi starter. This experiment shows that there is greater proteolysis in the butter from raw cream and also greater changes during storage than in pasteurized cream butter.

Samples 232 B1 and 232 B2 were made from raw cream held three days at 30 to 35°, 232 B2 being inoculated with B. bulgaricus starter. Samples 232 B3 and 232 B4 were from raw cream held four days, 232 B4 being inoculated with peptonizing spore-forming aerobes. Since there is no appreciable difference in the determinations on the butters in this experiment between the inoculated cream samples and those not inoculated, it is evident that the cream already contained enzymes or organisms sufficient to produce considerable proteolysis.

TABLE 4

Showing results on experimental butter from neutralized clean acid cream made at Grove City, 1920

NUMBER	ACIDITY OF CREAM	SCORE OF BUTTER			PER CENT OF TOTAL NITROGEN IN BUTTER AS:					
		Fresh	Storage	Ice box	Amino nitrogen in acetic acid and picric acid filtrate			Nitrogen not precipitated by phosphotungstic acid		
					Fresh	Storage	Ice box	Fresh	Storage	Ice box
217 B1	0.35	91	92½	86	1.1	1.9	3.6	2.7	4.3	7.1
218 B1	0.45	91	92½	87	2.8	3.0	5.6	4.6	5.4	9.5
221 B1	0.51	92	92	89	1.9	2.9	3.8	4.2	4.2	6.0
222 B1	0.55	92	93	89	1.5	2.0	2.2	2.9	2.8	4.1
220 B1	0.58	92	93	86	2.6	3.3	3.1	5.2	4.4	4.8
216 B1	0.60	90	93	91	2.7	3.0	2.8	3.8	5.4	4.8
225 B1	0.60	90½	92	89	2.1	3.3	2.9	4.1	4.1	5.8
226 B1	0.62	91	92	89	1.8	2.6	3.0	3.7	3.6	4.3
228 B1	0.63	92	92	89	1.5	2.5	3.0	3.9	3.7	5.3
224 B1	0.65	91	92	88	3.3	3.4	4.9	5.1	5.9	8.2
219 B1	0.67	92	93	91½	1.9	1.9	2.3	3.5	2.9	4.4
227 B1	0.67	91	92	89	2.4	3.7	4.9	4.0	5.3	7.3
Maximum					3.3	3.4	5.6	5.2	5.9	9.5
Minimum					1.1	1.9	2.2	2.7	2.8	4.1
Mean					2.1	2.8	3.5	4.0	4.4	6.0

Samples 235 B1, 235 B2, and 235 B3, were made from pasteurized cream held at room temperature 3 days, the first being inoculated with B. lactis acidi starter, the second with B. aerogenes, B. coli, and B. lactis acidi, and the third with peptonizing spore-forming aerobes. These three samples showed practi-

TABLE 5

Showing results on experimental butter from treated cream made at Grove City, 1920

SAMPLE NUMBER	CREAM					SCORE OF BUTTER			PER CENT OF TOTAL NITROGEN IN BUTTER AS:					
		INOCULATED WITH	Held		Acidity	Fresh	Storage	Ice box	Amino nitrogen in acetic acid and picric acid filtrate			Nitrogen not precipitated by phosphotungstic acid		
			Days	Temperature					Fresh	Storage	Ice box	Fresh	Storage	Ice box
				°C										
230 B1	Pasteurized	Oidium lactis	2	Room	0.67	90	93	88	1.9	3.0	2.8	3.4	3.4	5.3
231 B1	Raw	Oidium lactis	1	Room	0.69	89	90	91*	2.9	4.1	4.0*	4.8	5.1	6.6*
236 B1	Raw		9	20–35	0.96	87	89	84	2.8	3.9	4.5	4.9	6.8	7.8
236 B2	Pasteurized	Oidium lactis	9	20–35	0.93	90	89	87	2.1	2.5	2.6	2.9	4.5	4.7
236 B3	Pasteurized	B. lactis acidi	9	20–35	0.97	88	90½	83	1.0	2.2	3.8	3.1	4.2	8.7
232 B1	Raw		3	30–35	0.77	88	92	88	4.1	4.0	3.9	6.0	7.5	5.9
232 B2	Raw	B. bulgaricus	3	30–35	0.87	91	90	90*	3.5	4.6	4.3*	5.9	7.0	7.6*
232 B3	Raw		4	30–35	0.87	88	90	84	3.5	4.3	5.2	5.9	6.3	7.6
232 B4	Raw	Peptonizing spore forming aerobes	4	30–35	0.92	89	90	82	3.2	4.0	6.6	6.2	6.7	7.7
235 B1	Pasteurized	B. lactis acidi	3	Room	0.70	90	90	90½	1.3	1.6	1.7	2.2	2.9	4.3
235 B2	Pasteurized	B. aerogenes, B. coli and B. lactis acidi	3	Room	0.74	91	91	90	1.7	1.7	1.5	2.3	2.7	4.0
235 B3	Pasteurized	Peptonizing spore forming aerobes	3	Room	0.70	90½	91	92	1.5	2.0	1.6	3.1	3.1	5.1
237 B1	Pasteurized	Peptonizing spore forming aerobes	6 3	Room 37–40	1.13	88	83	86	3.0	3.9	3.7	5.1	8.8	9.5
238 B1	Raw	B. aerogenes (developed B. coli bulgaricus)	6 3	Room 37–40	1.76	87	85	83	4.0	5.6	5.6	5.5	7.2	8.2

* These samples were not put in ice box before analyses.

cally the same amount of amino acids and nitrogen not precipitated by phosphotungstic acid as the high grade regular run butters, as shown in table 3.

In order to determine whether more proteolysis would take place if the peptonizers were given a longer time to act, experiment 237 B1 was carried out. Pasteurized cream was inoculated with the peptonizing culture and held at room temperature six days, then at 37 to 40° for three days. The butter from this cream scored only 88 when fresh and fell down greatly in storage; however, the amino nitrogen and nitrogen not precipitated by phosphotungstic acid were only slightly higher than found in neutralized clean acid cream butter, as shown in table 4. Sample 238 Bl was made from raw cream inoculated with B. coli and B. aerogenes and held under the same conditions as 237 B1, when the cream was found to contain bacteria, predominantly B. bulgaricus. The butter from this cream was considerably higher in amino nitrogen and slightly higher in nitrogen not precipitated by phosphotungstic acid than the butters from neutralized clean acid cream.

SUMMARY

Proteolysis of cream, as shown by increase in amino nitrogen and nitrogen not precipitated by phosphotungstic acid in the corresponding butters begins as soon as the cream develops acidity of 0.2 or 0.3 per cent. As these butters were held in storage, there was found to be an increase in the soluble nitrogen compounds, the increase on butters made from sweet cream being slight, while the butters made from neutralized sour cream showed a somewhat greater increase. The greatest per cent of soluble nitrogen, when the butter was fresh, and also the greatest increase during storage, was on butter made from cream which had been allowed to sour before being pasteurized.

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STUDIES IN MILK SECRETION

XI. RELATION BETWEEN THE BUTTERFAT PERCENTAGE OF ONE LACTATION AND THE BUTTERFAT PERCENTAGE OF A SUBSEQUENT LACTATION IN GUERNSEY ADVANCED REGISTRY CATTLE[1]

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In a previous paper it has been shown that a milk record of Guernsey cows making the advanced registry predicts quite exactly what the subsequent record of these same cows will be when put on retest. In other words, physiologically speaking, the control mechanism of the cow when once established regulates quite accurately what the subsequent production of that cow will be. It remains to be shown whether this control mechanism or some similar one will regulate the butterfat percentage of the cow to a similar degree. As important perhaps as a knowledge of whether a butterfat record of a cow is any prediction of her calf's potential possibilities as a milk producer is this knowledge of the worth of one record as an indication of the producing capacity of the cow herself in subsequent lactations. In fact, this knowledge is at the basis of all dairy work, for without it no culling of dairy cattle would be possible, nor would it be profitable to test cattle since the record would be simply an empty number without further significance. It is the purpose of this paper to attempt to solve this relationship and show its true value for the Guernsey breed.

MATERIAL

The data used in this investigation are the same as those of the investigation on milk yield. The American Guernsey Cattle

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[1] Paper from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 145. This paper is one of a series of investigations in animal husbandry the continued prosecution of which has been made possible by a grant to the author from The Rockefeller Institute for Medical Research.

Club in its advanced registry tabulates the records of the cows which make the requirements for entry. In volume 31 of this registry there are found to be 738 possible pairs of these test and retest cows under ten years old. From these data the necessary tables were made to determine the degree of relationship which exists between the butterfat percentage of one lactation and that of another lactation. These tables are shown in the appendix to this paper. Because of the slight decrease of the butterfat percentage with advancing age of the cows in the Guernsey breed, it was considered advisable to divide the data into year groups for age of the cows up to the age of six years. The cows whose ages were seven, eight, and nine years were grouped together.

MEAN BUTTERFAT PERCENTAGE OF GUERNSEY TEST AND RETEST COWS

Table 1 gives the average butter fat percentages for the different age groups. The columns represent the mean butterfat percentages of the cows whose ages are indicated above the column. The groups of cows within that age for which the butterfat percentages are subsequently correlated are shown at the left as the age at which the retest was made. Thus, the first mean in the two-year column, 5.15 ± 0.03, shows that these two-year-olds' mean butter fat percentage was 5.15 ± 0.03 per cent and that these same cows were subsequently tested at three years old. Similarly the mean butterfat percentage of the two-year-old cows subsequently retested at four years old was 5.09 ± 0.03 per cent. The mean butterfat percentage of the three-year-old cows tested at two years is given in column headed three years in the two-year row as 5.12 per cent. No striking differences appear in the butterfat percentage of any age group of cows. The butterfat percentage declines with age, it is true, but this is in line with the fact that butterfat percentage does decline slightly in the Jersey, Guernsey, and Ayrshire breeds.

It will be remembered from the previous paper (6) that there was a very distinct increase of the retest cow's milk yield as compared with the milk yield of the cow on first test even within

TABLE 1

Average butter-fat percentage of Guernsey test and retest cows

AGE WITH WHICH CORRELATED	AGE CORRELATED						
	2 years	3 years	4 years	5 years	6 years	7, 8, 9 years	7 years
years							
2		5.12 ± 0.03	5.02 ± 0.03	5.02 ± 0.05	4.83 ± 0.04	4.80 ± 0.04	
3	5.15 ± 0.03		5.19 ± 0.04	4.90 ± 0.05	5.08 ± 0.05	4.92 ± 0.05	
4	5.09 ± 0.03	5.22 ± 0.04		5.09 ± 0.05	4.98 ± 0.05	4.80 ± 0.06	
5	5.07 ± 0.04	4.90 ± 0.04	5.11 ± 0.05		5.02 ± 0.07	4.89 ± 0.06	
6	4.94 ± 0.04	5.19 ± 0.05	5.05 ± 0.04	5.04 ± 0.06		4.95 ± 0.05	
7, 8, 9	5.05 ± 0.04	5.21 ± 0.05	4.97 ± 0.06	4.95 ± 0.06	4.99 ± 0.05		5.01 ± 0.07
8 and 9							4.95 ± 0.06

the same age groups. This increase in milk yield appears to be due to the development of the cow, to special treatment accorded the cow in retest, or to the education of her owner in the proper handling of cattle for advanced registry testing. In either case the result is brought about largely as an environmental effect, the consequences of the effect being sufficiently large to justify careful attention to this phase of the training of cattle and men for advanced registry testing.

The effect of this training is all on the milk yield, for if an examination is made of table 1 to compare the records of test and retest cows, it is seen that they do not differ appreciably in their mean butterfat percentage within the same age groups. The possibilities of using this developmental effect in increasing milk seem to be limited to the increasing of the milk yield and not to increasing the butterfat percentage. The butterfat percentage appears quite stable and resistant to such an influence.

VARIATION OF THE BUTTERFAT PERCENTAGE OF GUERNSEY TEST AND RETEST COWS

Table 2 gives the variation in butterfat percentage which these Guernsey cows showed in their first and second tests. This variation is recorded as the standard deviation. Within limits of three times the standard deviation on either side of the mean butterfat percentage of table 1 are included practically all the observed butterfat percentages of this group of cows. The arrangement of table 2 is the same as that of table 1.

The variability with the different age groups appears to be at random. Of the standard deviation for the individual ages that for the two-year-olds subsequently tested at six years old is probably too low. The variability of the seven-year group tested again at eight or nine years is high. These differences are probably due to random sampling and not to any real differences. The other standard deviations vary within rather narrow limits. The variability expressed in terms of the mean ranges from 7.3 to 10.1 per cent. This variation is closely similar to like data on the butterfat percentage of purebred Jersey cows (5), Ayrshire cows (8), and Holstein-Friesian cows (2).

TABLE 2

Differences between butterfat percentage for Guernsey retest cows in first and second tests

AGE WITH WHICH CORRELATED	AGE CORRELATED						
	2 years	3 years	4 years	5 years	6 years	7, 8, 9 years	7 years
years							
2		0.456 ± 0.021	0.447 ± 0.020	0.444 ± 0.031	0.413 ± 0.030	0.440 ± 0.032	
3	0.440 ± 0.020		0.433 ± 0.028	0.496 ± 0.036	0.404 ± 0.033	0.466 ± 0.036	
4	0.429 ± 0.019	0.491 ± 0.03		0.458 ± 0.038	0.458 ± 0.034	0.449 ± 0.043	
5	0.449 ± 0.029	0.423 ± 0.031	0.454 ± 0.037		0.438 ± 0.049	0.486 ± 0.041	
6	0.362 ± 0.026	0.401 ± 0.033	0.452 ± 0.033	0.388 ± 0.044		0.497 ± 0.038	
7, 8, 9	0.427 ± 0.030	0.461 ± 0.038	0.419 ± 0.040	0.487 ± 0.041	0.449 ± 0.035		0.507 ± 0.052
8 and 9							0.444 ± 0.045

TABLE 3

Correlation coefficients between the butterfat percentages of one lactation and those of another lactation

AGE WITH WHICH CORRELATED	AGE CORRELATED						
	2 years	3 years	4 years	5 years	6 years	7, 8, 9 years	7 years
years							
2		0.822 ± 0.021	0.780 ± 0.025	0.780 ± 0.036	0.684 ± 0.054	0.637 ± 0.060	
3	0.822 ± 0.021		0.829 ± 0.028	0.802 ± 0.037	0.737 ± 0.053	0.764 ± 0.048	
4	0.780 ± 0.025	0.829 ± 0.028		0.800 ± 0.046	0.868 ± 0.026	0.736 ± 0.062	
5	0.780 ± 0.036	0.802 ± 0.037	0.800 ± 0.046		0.812 ± 0.038	0.893 ± 0.024	
6	0.684 ± 0.054	0.737 ± 0.053	0.868 ± 0.026	0.812 ± 0.038		0.882 ± 0.024	
7, 8, 9	0.637 ± 0.060	0.764 ± 0.048	0.736 ± 0.062	0.893 ± 0.024	0.882 ± 0.024		
8 and 9							0.838 ± 0.043
Average.......	0.741	0.791	0.803	0.817	0.797	0.782	0.838

RELATION BETWEEN THE BUTTERFAT PERCENTAGE OF THE FIRST TEST AND OF THE RETEST

With these data at hand it is now possible to measure the degree of reliance which may be placed in one advanced registry record for butterfat percentage as an indication of what that cow may do on another advanced registry test. It is the answer to this problem which makes the advanced registries worthy or unworthy. Table 3 gives the correlation coefficients for one lactation's butterfat percentage record with that of another.

Study of table 3 shows that the correlation coefficients for the butterfat percentage of one lactation correlated with that of another lactation are high for that kind of data. The average weighted correlation coefficient for all tests is 0.792 when each observation is equally weighted. The differences in the individual correlation coefficients appear to be due to chance. Such being the case, the results lead to the important practical conclusion that a cow beginning her lactating career as a two-year-old with a high butterfat percentage may be expected to duplicate this relatively high performance. The first lactation records as to the butterfat percentage which a given cow will produce are, then, good indices of what may be expected in future years. Selection of cows on the basis of such records is profitable to the dairyman.

Some comparative records along these lines are of interest. The data given in table 4 furnish this information.

Table 4 (3, 4, 5, 6, 7) shows that a butterfat percentage record of advanced registry Guernsey cows predicts more accurately the butterfat percentage of a subsequent lactation than an advanced registry milk record predicts the milk yield of a subsequent lactation. Thus, the average correlation coefficient between the various butterfat percentages of different lactations is 0.792, while the average correlation coefficient of the various milk yields of different lactations is 0.696, or the butterfat record is approximately 1.1 times as good an index of the subsequent lactation records as is a milk production record an index of the subsequent lactations' milk yields.

TABLE 4

Correlation coefficients between characters of economic importance

CHARACTER	BREED	CORRELATION	AUTHORITY
Butterfat percentage and butterfat percentage	Guernsey advanced registry	0.637 to 0.893	This paper
Milk yield and milk yield	Guernsey advanced registry	0.462 to 0.811	Gowen (6)
Butterfat percentage and butterfat percentage	Jersey pure-bred herd	0.247 to 0.678	Gowen (5)
Milk yield and milk yield	Jersey pure-bred herd	0.214 to 0.731	Gowen (4)
Monthly egg yield and other 11-months' production	White Leghorn	0.240 to 0.573	Harris and Blakeslee (7)
Milk yield and score (conformation)	Jersey registry of merit	−0.070 to +0.194	Gowen (3)

It will be noted that an advanced registry record of Guernsey cows, whether for milk yield or butterfat percentage, is a more reliable guide to what those cows will do in a subsequent advanced registry test than are the records of a pure-bred herd of Jersey cattle. Advanced registry cattle are a selected group of cattle. The comparison of these selected Guernsey cows with those of a pure-bred herd of Jerseys where no selection has been practiced indicates that the reliance which may be placed in the butterfat percentage and milk records of an unselected group of cattle is slightly less than can be placed in the records of the selected group. This does not mean that the records of the unselected group may not be as accurately taken as the records of the advanced registry group. The correlations in all cases are high for butterfat percentage or for milk yield. Such high correlation coefficients indicate that the individual cows are innately differentiated in their capacity for producing a high or low butterfat percentage or a high or low milk yield.

The correlation coefficients between the monthly egg production and the other-eleven-months' production of the White Leghorn hens show a similar range to those of the various butterfat percentages except that they are considerably lower in value. Such being the case, a greater reliance may be placed in a milk or butterfat percentage record than may be placed in an egg record.

Conformation has played and is playing a large part in the selection of cows for milk production. It does not occupy so wide a place in the selection of cows for butterfat percentage, in fact has little relation to it. The selection of cows is based on the hope of future returns from these cows as milk and butterfat producers. Table 4 brings out in striking comparison the relative values of a milk record and a judgment on conformation as an indicator of the cow's future production. Thus if the character having the highest relation to milk production total score, is compared with a record for milk yield, it is seen that a milk record of Guernsey advanced registry cows is 3½ times as good an indicator of what the cow will do in a subsequent lactation as is any point of conformation. Not only that but conformation throws little or no light on a cow's butterfat percentage, whereas the Babcock test applied to a cow's milk indicates quite clearly what that cow's milk will test for butterfat in a subsequent lactation. It seems doubtful if greater proof is needed of the desirability of testing cattle.

One other thing is needed to make any record of value in predicting another, the factor necessary to convert one record into another must be known.

TABLE 5

Equations to predict the probable butter-fat percentage of Guernsey advanced registry cows on second test

$\text{BF}\ \%_2 = 1.088 + 0.793\ \text{bf}\ \%_3$	$\text{BF}\ \%_3 = 0.735 + 0.852\ \text{bf}\ \%_2$
$\text{BF}\ \%_2 = 1.318 + 0.750\ \text{bf}\ \%_4$	$\text{BF}\ \%_4 = 0.893 + 0.812\ \text{bf}\ \%_2$
$\text{BF}\ \%_2 = 1.105 + 0.790\ \text{bf}\ \%_5$	$\text{BF}\ \%_5 = 1.109 + 0.771\ \text{bf}\ \%_2$
$\text{BF}\ \%_2 = 2.037 + 0.600\ \text{bf}\ \%_6$	$\text{BF}\ \%_6 = 0.982 + 0.780\ \text{bf}\ \%_2$
$\text{BF}\ \%_2 = 2.087 + 0.617\ \text{bf}\ \%_{7-8+9}$	$\text{BF}\ \%_{7,8,9} = 1.484 + 0.657\ \text{bf}\ \%_2$
$\text{BF}\ \%_3 = 0.341 + 0.940\ \text{bf}\ \%_4$	$\text{BF}\ \%_4 = 1.377 + 0.730\ \text{bf}\ \%_3$
$\text{BF}\ \%_3 = 1.556 + 0.683\ \text{bf}\ \%_5$	$\text{BF}\ \%_5 = 0.276 + 0.943\ \text{bf}\ \%_3$
$\text{BF}\ \%_3 = 1.479 + 0.731\ \text{bf}\ \%_6$	$\text{BF}\ \%_6 = 1.223 + 0.743\ \text{bf}\ \%_3$
$\text{BF}\ \%_3 = 1.326 + 0.790\ \text{bf}\ \%_{7-8+9}$	$\text{BF}\ \%_{7,8,9} = 1.066 + 0.739\ \text{bf}\ \%_3$
$\text{BF}\ \%_4 = 1.076 + 0.792\ \text{bf}\ \%_5$	$\text{BF}\ \%_5 = 0.969 + 0.807\ \text{bf}\ \%_4$
$\text{BF}\ \%_4 = 0.783 + 0.856\ \text{bf}\ \%_6$	$\text{BF}\ \%_6 = 0.539 + 0.880\ \text{bf}\ \%_4$
$\text{BF}\ \%_4 = 1.679 + 0.687\ \text{bf}\ \%_{7-8+9}$	$\text{BF}\ \%_{7,8,9} = 0.870 + 0.790\ \text{bf}\ \%_4$
$\text{BF}\ \%_5 = 1.432 + 0.719\ \text{bf}\ \%_6$	$\text{BF}\ \%_6 = 0.392 + 0.918\ \text{bf}\ \%_5$
$\text{BF}\ \%_5 = 0.567 + 0.896\ \text{bf}\ \%_{7-8+9}$	$\text{BF}\ \%_{7,8,9} = 0.484 + 0.891\ \text{bf}\ \%_5$
$\text{BF}\ \%_6 = 1.051 + 0.796\ \text{bf}\ \%_{7-8+9}$	$\text{BF}\ \%_{7,8,9} = 0.073 + 0.977\ \text{bf}\ \%_6$
$\text{BF}\ \%_7 = 0.267 + 0.957\ \text{bf}\ \%_{8+9}$	$\text{BF}\ \%_{8,9} = 1.281 + 0.733\ \text{bf}\ \%_7$

PREDICTION OF RETEST BUTTERFAT PERCENTAGE FROM THE FIRST TEST BUTTERFAT PERCENTAGE

These conversion factors may be put in the form of equations to predict one of the variables from another. These equations to predict the probable butterfat percentage of one lactation from that of another have been calculated for these advanced registry Guernsey cows. They are given in table 5.

In the equations of table 5, BF percentage represents the desired predicted butterfat percentage at the subscript age, and bf percentage indicates the butterfat percentage at the age given as the subscript to the bf percentage. Thus a cow at two years old gives a milk whose butterfat percentage is 6.0 per cent, which would be the expected advanced registry butterfat percentage at six years of age. We find the BF percentage of six years and the bf percentage of two years in the fourth equation of column 2. This equation is

$$\text{BF percentage}_6 = 0.982 + 0.780 \text{ bf percentage}_2$$

substituting, we have BF $\text{percentage}_6 = 0.982 + 0.780 \times 6.0$, or the expected butterfat percentage at six years is 5.662 per cent. By the same process the required probable butterfat percentage of any age may be found.

SUMMARY

This paper presents data to show the reliability of an advanced registry record of Guernsey cattle in predicting what the cow's butterfat percentage will be in a subsequent advanced registry retest for other lactations. The principle facts resulting from this study may be briefly stated as follows.

Unlike milk yield, the butterfat percentage of these Guernsey advanced registry cows shows no increase on retest. It remains approximately the same in the retest as in the first test.

The variation of the butterfat percentage is closely similar to that of other breeds of cattle.

The relation of the butterfat percentage of one lactation to that of another is high, ranging from 0.637 to 0.893 in terms of the correlation scale. The average correlation coefficient is 0.792. This average is $1\frac{1}{10}$ times as high as that for milk yield of these same cows, or a butterfat percentage record may be more accurately predicted from a previous test than can a record for milk yield be predicted from a previous test. Comparison of these results with records of a pure-bred Jersey herd for the relation of one lactation to another indicates that the advanced registry records predict a subsequent advanced registry performance more accurately than would be expected to be the case for all Guernsey cows.

A comparison of the value of a month's egg record in predicting the other eleven months' record with Guernsey butterfat

percentage records shows that a Guernsey butterfat percentage record predicts more accurately the subsequent butterfat percentage record than does an egg record predict the subsequent performance of the hen.

Comparison of scoring as a method of selecting cattle for milk yield or butterfat percentage with an advanced registry record for selecting milch cows shows the advanced registry record to be several times more valuable than the score card.

Equations are presented to determine from one lactation's advanced registry butterfat percentage record what the probable butterfat percentage record at a subsequent lactation will be.

APPENDIX

TABLES SHOWING THE CORRELATION SURFACE FOR THE VARIABLE BUTTER-FAT PERCENTAGE OF ONE LACTATION WITH THE BUTTER-FAT PERCENTAGE OF ANOTHER LACTATION. EACH LACTATION IS AT A KNOWN AGE

3-YEAR-OLDS' BUTTER-FAT PERCENTAGE	2-YEAR-OLDS' BUTTER-FAT PERCENTAGE												
	4.0 to 4.2	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2 to 6.4	
3.8 to 4.0	1												1
4.0		1	1										2
4.2	1			2									3
4.4		2	2	3									7
4.6	1		2	2	5	4							14
4.8				3	3	2	1	1					10
5.0				2	6	9	6	2	1				26
5.2						1	9	5	1	1			17
5.4						1	1	6				1	9
5.6						1	2	2	4				9
5.8						1		2	1	1			5
6.0 to 6.2										1	2		3
	3	3	5	12	14	19	19	18	7	3	2	1	106

4-YEAR-OLDS' MILK YIELD (POUNDS)	2-YEAR-OLDS' BUTTER-FAT PERCENTAGE												
	3.8 to 4.0	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0 to 6.2	
3.8 to 4.0	1		1										2
4.0			1	1									2
4.2		1	3	2	1								7
4.4			1	1	2	3	2						9
4.6				2	3	3	2		1				11
4.8		1		1	7	5	7	1	5				27
5.0							8	1	3				12
5.2						2	3	10	6	1	1		23
5.4							3	4	3	2	1		13
5.6								1	3	1	1		6
5.8													
6.0 to 6.2								1		1		1	3
	1	2	6	7	13	13	25	18	21	5	3	1	115

5-YEAR-OLDS' BUTTER-FAT PERCENTAGE	2-YEAR-OLDS' BUTTER-FAT PERCENTAGE											
	4.0 to 4.2	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0 to 6.2	
4.0 to 4.2		1										1
4.2	1		1									2
4.4			3	5								8
4.6		1	1	1	1	2	1	1				8
4.8				1	1	2						4
5.0			2		1	4	3	1	1			12
5.2					1	3	2	2	1			9
5.4							1	3				4
5.6									2		1	3
5.8										1		1
6.0												
6.2 to 6.4								1				1
	1	2	7	7	4	11	7	8	4	1	1	53

6-YEAR-OLDS' BUTTER-FAT PERCENTAGE	2-YEAR-OLDS' BUTTER-FAT PERCENTAGE									
	4.0 to 4.2	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6 to 5.8	
3.8 to 4.0		1								1
4.0				1						1
4.2	1			2	1					4
4.4		1	4	2	1					8
4.6				1	4	1		1		7
4.8		1		1	1	4		2		9
5.0					1	3	2			6
5.2					1		1		1	3
5.4						1	2			3
5.6 to 5.8							2			2
	1	3	4	7	9	9	7	3	1	44

7-, 8-, AND 9-YEAR-OLDS' BUTTER-FAT PERCENTAGE	2-YEAR-OLDS' BUTTER-FAT PERCENTAGE								
	4.2 to 4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6 to 5.8	
4.0 to 4.2	1	3							4
4.2	1	1	2	1					5
4.4	1			2	1	1			5
4.6	1		1			2	4	1	9
4.8			2	1	4	1			8
5.0			1	1	2		2		6
5.2						1	1	1	3
5.4								2	2
5.6									
5.8 to 6.0						1	1		2
	4	4	6	5	7	6	8	4	44

4-YEAR-OLDS' BUTTER-FAT PERCENTAGE	3-YEAR-OLDS BUTTER-FAT PERCENTAGE										
	4.2 to 4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0 to 6.2	
4.0 to 4.2	1										1
4.2		1									1
4.4		3									3
4.6		3	2	2							7
4.8			1	2	3						6
5.0				1	4	1	1				7
5.2			1	1	2		3	2	1	1	11
5.4					2	3	3	2	1		11
5.6					1	1			2	1	5
5.8										1	1
6.0 to 6.2									1	1	2
	1	7	4	6	12	5	7	4	5	4	55

5-YEAR-OLDS' BUTTER-FAT PERCENTAGE	3-YEAR-OLDS' BUTTER-FAT PERCENTAGE									
	4.0 to 4.2	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6 to 5.8	
4.0 to 4.2	2	1	1							4
4.2		2	2							4
4.4		1		2	1					4
4.6			1	3	2			1		7
4.8				4	2		1			7
5.0					1	2	2			5
5.2					1	1	2		1	5
5.4							2	3		5
5.6										
5.8										
6.0 to 6.2					1				1	2
	2	4	4	9	8	3	7	4	2	43

6-YEAR-OLDS' BUTTER-FAT PERCENTAGE	3-YEAR-OLDS' BUTTER-FAT PERCENTAGE								
	4.4 to 4.6	4.6	4.8	5.0	5.2	5.4	5.6	5.8 to 6.0	
4.2 to 4.4	1	1							2
4.4	1								1
4.6		4	2		1				7
4.8			1	2		1	1		5
5.0			1	1	1	3			6
5.2			1	2		1			4
5.4					1	1	1	1	4
5.6 to 5.8				1		2		2	5
	2	5	5	6	3	8	2	3	34

7-, 8-, AND 9-YEAR-OLDS' BUTTER-FAT PERCENTAGE	3-YEAR-OLDS' BUTTER-FAT PERCENTAGE										
	4.4 to 4.6	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2 to 6.4	
4.2 to 4.4	1		1								2
4.4	2	2	2				1				7
4.6	1		3		2	2					8
4.8			3	1							4
5.0					1		3				4
5.2				1		2	2				5
5.4						1	1	1			3
5.6											
5.8											
6.0											
6.2											
6.4 to 6.6										1	1
	4	2	9	2	3	5	7	1		1	34

5-YEAR-OLDS' BUTTER-FAT PERCENTAGE	4-YEAR-OLDS' BUTTER-FAT PERCENTAGE									
	4.2 to 4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8 to 6.0	
4.2 to 4.4	1	1								2
4.4	1		1							2
4.6		1	2	3	2					8
4.8		1								1
5.0			2		2		1			5
5.2				1		3	2	2		8
5.4							3		1	4
5.6										
5.8									1	1
6.0 to 6.2						1		1		2
	2	3	5	4	4	4	6	3	2	33

6-YEAR-OLDS' BUTTER-FAT PERCENTAGE	4-YEAR-OLDS' BUTTER-FAT PERCENTAGE										
	4.2 to 4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0 to 6.2	
4.0 to 4.2	2										2
4.2		1		1							2
4.4	1	3	1	1							6
4.6	1		3	1							5
4.8				4	2		1				7
5.0				1	1	2	2				6
5.2				1		2	2				5
5.4				1		1	4				6
5.6									1	1	2
5.8											
6.0										1	1
6.2 to 6.4											
	4	4	4	10	3	5	9	1	1	1	42

7-, 8-, AND 9-YEAR-OLDS' BUTTER-FAT PERCENTAGE	4-YEAR-OLDS' BUTTER-FAT PERCENTAGE								
	4.2 to 4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6 to 5.8	
4.0 to 4.2		1	2						3
4.2	1	1	1	1					4
4.4			1	1					2
4.6	1					1			2
4.8	1			1	3				5
5.0				1	1	1	1		4
5.2						1		1	2
5.4 to 5.6					1			2	3
	3	2	4	4	5	3	1	3	25

6-YEAR-OLDS' BUTTER-FAT PERCENTAGE	5-YEAR-OLDS' BUTTER-FAT PERCENTAGE								
	4.4 to 4.6	4.6	4.8	5.0	5.2	5.4	5.6	5.8 to 6.0	
4.0 to 4.2	1								1
4.2	1								1
4.4									
4.6	1	1	1						3
4.8		1	3						4
5.0				2	1				3
5.2					2		1		3
5.4								1	1
5.6					1				1
5.8 to 6.0					1				1
	3	2	4	2	5		1	1	18

7-, 8-, AND 9-YEAR-OLDS' BUTTER-FAT PERCENTAGE	5-YEAR-OLDS' BUTTER-FAT PERCENTAGE													
	4.0 to 4.2	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4 to 6.6	
4.0 to 4.2		1	2											3
4.2	1	1		1										3
4.4		1												1
4.6			2	2	1	1								6
4.8			1	1	1	1	2							6
5.0					1	3	2							6
5.2						2	1	1						4
5.4								1	1					2
5.6														
5.8														
6.0														
6.2														
6.4 to 6.6													1	1
	1	3	5	4	3	7	5	2	1				1	32

7-, 8-, AND 9-YEAR-OLDS' BUTTER-FAT PERCENTAGE	6-YEAR-OLDS' BUTTER-FAT PERCENTAGE										
	4.2 to 4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0 to 6.2	
4.0 to 4.2		1									1
4.2	1		2								3
4.4	3		3		1						7
4.6		2		2	1						5
4.8			1	3	1						5
5.0				1	4	2					7
5.2					3	1	1				5
5.4					1			1			2
5.6									1		1
5.8											
6.0										1	1
6.2											
6.4 to 6.6										1	1
	4	3	6	6	11	3	1	1	1	2	38

8-, AND 9-YEAR-OLDS' BUTTER-FAT PERCENTAGE	7-YEAR-OLDS' BUTTER-FAT PERCENTAGE													
	4.0 to 4.2	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4 to 6.6	
3.8 to 4.0	1													1
4.0														
4.2			1											1
4.4		1		1	1	1								3
4.6				2										2
4.8				4	1	1								6
5.0						1								1
5.2					1		2	2						5
5.4							1							1
5.6 to 5.8									1				1	2
	1	1	1	6	3	3	3	2	1				1	22

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STUDIES IN THE GROWTH AND NUTRITION OF DAIRY CALVES

VI. THE ADDITION OF HAY AND GRAIN TO A MILK RATION FOR CALVES

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The necessity of investigating the effects of rations selected from limited sources is now recognized as of vital importance in arriving at a true idea of certain nutritional processes. In order to determine the true or relative value of any feed for a given class of animals, it is necessary that it be fed with a wide variety of other feeds and also as the sole constituent of the ration, if it is of such a nature as to render this possible. A thorough understanding of the physiological value of any feed can only be arrived at after a series of correlated investigations, the results of which can be studied as a group.

The work outlined here was undertaken to expand results reported in paper V of this series and to determine the relative values of rations consisting of milk, milk and mixed grains, and milk and alfalfa hay for young calves.

RÉSUMÉ OF PREVIOUS WORK

Investigations bearing directly on the problem under consideration are limited in number as little work of this character has been undertaken with farm live stock. There are, however, reports of investigations with laboratory animals which aid to some extent in the explanation of the results obtained.

The results available on the use of limited rations for ruminants are meager. Plumb (51) fed one pen of calves on whole milk and two pens on skim milk, for a period of two to three months without observing any bad effects from the limited ration. Sanborn (52) placed a calf weighing 180 pounds on a ration of milk and grain, and the animal is reported to have eaten the sawdust used as bedding and died of indigestion.

In an attempt to grow cattle without the use of roughages, Davenport (39) found that grain fed in amounts up to half a bushel daily to a five-month old calf did not satisfy the craving for feed. Disturbances of the nerve centers and swelling of the joints were noticed. A second calf, fed exclusively on skim milk until seven months of age, when it was in quite poor condition, was then placed on coarse feed and recovered rapidly. A third individual, fed milk and grain, was extremely reduced in condition at five months of age, but recovered when allowed hay. A fourth calf, which received no roughage, died at three months of age. A post-mortem examination showed that the muscles were hard and firm and no internal fat was present.

That growth and reproduction were seriously affected by limiting the ration of dairy heifers to the products of a single cereal plant was found by Hart, McCollum, Humphrey and Steenbock (45, 46). It was also reported in paper V of this series that calves could not exist for extended periods on a ration of whole milk alone.

In an investigation with hogs, Burnett (35, 36) found that limiting the ration to corn markedly affected bone growth and development and the breaking strength of the bones of the legs. In the case of work done by McCollum and reported by Henry (47) it was found that a sow could be raised to maturity and reproduce normally with milk as the sole feed, though Evvard and Glatfelter (42) report that better success was obtained in the raising of orphan pigs where eggs, tomato juice or orange juice were added to the ration than where milk alone was fed.

It has been stated by Forbes (43) that the specific effects of feeds on growing animals are due largely to the mineral elements in the feed and especially to the relation between the calcium and magnesium, while the importance of the vitamines has been emphasized by many and the work of this character, though little of it with ruminants, has been summarized quite completely by Blunt and Wang (32, 33). However, Dutcher, Kennedy and Eckles (41) report that the milk of cows on pasture is richer in water soluble C than is that of cows on winter feed.

EXPERIMENTAL WORK

In this work six calves were used, of which five were bulls and the other was presumed to be a freemartin as it was twinned with a bull. All but the freemartin were grades. The calves were allowed to suck their dams for a few days after birth and were then put on the experimental rations. They were divided into three lots and information concerning the individuals is given in table 38.

After the calves were taken from their dams, milk was fed to them three times daily in amounts indicated by their ability to handle it. Salt was accessible at all times and they had access to water for several hours daily though they were confined in pens. In addition, lot II was allowed to consume at free will a grain mixture consisting of 5 parts cracked corn, 2 parts ground oats, 2 parts wheat bran and 2 parts old-process linseed oil meal by weight, while lot III always had access to alfalfa hay.

TABLE 38

Animals used

	LOT I—MILK		LOT II—MILK AND MIXED GRAIN		LOT III—MILK AND ALFALFA HAY	
	Calf 479 (grade Guernsey)	Calf 489 (grade Holstein)	Calf 498 (grade Jersey)	Calf 502 (grade Guernsey)	Calf 488 (grade Holstein)	Calf 495 (Holstein)
Birth weight, pounds . . .	76	85	51	68	66	65
Sucking days.	4	3	5	6	2	5

Complete records of feed consumption were kept and these have been combined by thirty-day periods throughout the various experiments. The weights of the animals were determined on three successive days in the middle of each period and from these the live weights at the end of each experimental period were determined. Body measurements were obtained in a similar manner though only taken on one day. In the final computations it was assumed that the milk consumed during the few days that the animals sucked their dams was the same in amount as that consumed in a like period after hand feeding was started.

The calves did not all start on experiment at the same time, due to differences in date of birth, but in the tabulations they are kept together on the age basis. The inequalities near the finish are due to the fact that the experiments were all closed about the same time irrespective of the ages of the calves. However, to avoid complications, the records for the animals which lived throughout the work are given to the end of the last thirty-day period that was completed.

Rations

Lot I—milk. The calves in this group were fed a ration of whole milk throughout the trial. When they became weak and low in condition, alfalfa hay was introduced into the ration. This introduction took place at the beginning of period VIII for calf 479 and on the nineteenth day of period VI in the case of calf 489. For a few days the allowance of hay was limited and then it was given at free will.

Lot II—milk and grain. This group received milk throughout the experiment and in the latter part of period II the grain mixture was introduced and kept before the animals at all times. Calf 502 died on the sixteenth day of period V after consuming little feed during the last two weeks of its life. At the beginning of the sixth period, alfalfa hay was given to calf 498, at first in limited amounts, and later at free will.

Lot III—milk and alfalfa. These calves had milk throughout the experiment, and alfalfa hay was introduced in the latter part of the first period for calf 495 and in the early part of the second period for calf 498 and from then on was allowed at free will.

Growth of calves

The records of the increase in live weight and body measurements of the calves are indications of the suitability of the rations for the calves. For this reason the birth weights of the calves and their weights at the end of each completed thirty-day period are given, as are the body measurements taken, height at withers, depth of chest and width at hooks.

TABLE 39

Feed records

PERIOD	FEED							
	Whole milk		Alfalfa hay		Mixed grain		Salt	
	Lot I—milk ration							
	Calf 479	Calf 489	Calf 479	Calf 489	Calf 479	Calf 489	Calf 479	Calf 489
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
I	351	333					0.01	0.21
II	450	489					0.39	0.09
III	482	599					0.10	0.18
IV	540	630					0.10	0.33
V	630	630					0.29	0.27
VI	630	630		45*			0.26	0.18
VII	630	630		149			0.17	0.10
VIII	630	630	86	204			0.10	0.04
IX	630		121				0.15	
	Lot II—milk and mixed grain ration							
	Calf 498	Calf 502	Calf 498	Calf 502	Calf 498	Calf 502	Calf 498	Calf 502
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
I	218	216					0.04	0.06
II	246	267			2	10	0.09	0.08
III	270	270			26	32	0.12	0.06
IV	270	270			60	50	0.04	0.02
V	270	30†			82	82	0.02	0.01†
VI	270		59		57		0.08	
VII	270		108		30		0.10	
	Lot III—milk and alfalfa ration							
	Calf 488	Calf 495	Calf 488	Calf 495	Calf 488	Calf 495	Calf 488	Calf 495
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
I	298	307		9			0.02	0.04
II	462	450	27	36			0.02	0.05
III	450	450	73	96			0.11	0.08
IV	450	450	184	168			0.11	0.11
V	450	450	264	220			0.19	0.26
VI	450		313				0.45	

* Last twelve days of period VI for calf 489.

† Calf 502 died on the sixteenth day of period V and for two weeks prior to this consumed little feed.

TABLE 40

Live weights and body measurements of calves

PERIOD	GROUP						
	Normal	Lot I		Lot II		Lot III	
		Calf 479	Calf 489	Calf 498	Calf 502	Calf 488	Calf 495
				Live weight			
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
Birth	67	76	85	51	68	66	65
I	90	94	123	69	71	133	95
II	120	124	162	92	83	166	143
III	163	161	217	128	112	241	210
IV	211	177	271	165	113	322	266
V	262	212	315	187		399	339
VI	314	252	382	220		469	
VII	366	265	462	253			
VIII	413	289	530				
IX	452	323					
				Height at withers			
	inches	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*
I	28.7	30.4	29.9	26.5	28.1	29.1	28.6
II	30.7	31.5	32.5	27.5	29.0	31.4	30.7
III	32.9	33.3	35.0	29.4	30.4	33.5	32.2
IV	34.8	34.1	37.0	30.9	30.7	35.7	35.7
V	36.4	33.2	38.7	33.5		38.0	39.0
VI	38.4	36.4	40.5	35.0		40.8	
VII	39.8	40.2	42.8	36.2			
VIII	41.0	40.4	44.3				
IX	42.0	42.0					
				Depth of chest			
I	11.4	12.1	13.0	10.2	11.0	12.1	11.9
II	12.8	13.5	14.0	11.5	11.3	13.9	13.0
III	14.2	14.9	16.0	13.1	13.2	15.8	15.1
IV	15.4	15.7	17.2	14.4	13.8	17.1	16.6
V	16.7	16.7	18.4	15.0		18.2	17.8
VI	17.9	17.8	19.3	15.5		20.0	
VII	18.7	18.7	20.3	16.2			
VIII	19.5	18.6	20.5				
IX	20.3	19.3					

TABLE 40—*Continued*

PERIOD	GROUP						
	Normal	Lot I		Lot II		Lot III	
		Calf 479	Calf 489	Calf 498	Calf 502	Calf 488	Calf 495
	Width at hooks						
	inches	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*
I	6.7	6.5	7.4	5.9	6.3	6.8	6.9
II	7.5	7.3	8.6	7.0	6.9	7.8	8.0
III	8.5	8.0	9.8	8.1	7.1	9.0	9.6
IV	9.4	8.3	11.1	8.7	7.1	10.4	10.9
V	10.2	8.9	11.1	9.1		11.9	11.4
VI	11.2	9.8	11.4	10.0		13.0	
VII	11.8	9.9	12.4	10.4			
VIII	12.6	10.4	13.2				
IX	13.2	11.1					

In order that some idea may be gained as to the relative rates of increase in live weight and body measurements of the calves, it is necessary that some standard be used with which they may be compared. For this purpose the averages of similar measurements obtained on 40 normally fed heifers are included. This should form a satisfactory basis of comparison as all the experimental calves were young and the bulls were castrated so that it is not probable that sexual development would cause the two groups of figures to vary relatively.

Live weights and body measurements. When lot I is considered it is found that both animals is this group were heavier at birth then the average for the normal group. Calf 479 maintained its lead for only two months and then dropped below normal and continued to do so until alfalfa hay was introduced at the beginning of period VIII when it started to regain in rate of growth, calf 489, the heaviest of all, increased in live weight slowly and at the end of period V was of the same weight as the normal calves were at the end of period VI. During period VI, alfalfa was introduced and it immediately started to gain rapidly.

Both animals in lot II, though one was heavier and one lighter than the average for the normal group, fell far behind the normal weights as the work progressed. The calf 502 died, while no.

498 was given alfalfa at the end of period V and when the trial closed at the end of period VII it was beginning to approach the normal group in weight.

The alfalfa fed animals in lot III, though slightly lower in birth weight than the average for the normal group, always exceeded the normal group in live weight from the end of period I.

In regard to the body measurements it may be said that they did not vary uniformly though there was a very decided increase in the rates of growth of the calves in lot III compared with the normal calves, while the calves in lot II lagged behind the check. The calves in lot I did not show a great variation from the check group.

Increase in live weight and body measurements. The animals in lot III, fed alfalfa and milk throughout, showed a greater percentage increase in live weight and body measurements than did the normal group. In lot II, calf 502 showed a slower percentage increase than normal and eventually died. The other animal in this lot, calf 498, showed slow percentage gains in height but the other measurements were near normal, while the percentage increase in body weight was accelerated by the introduction of alfalfa hay into the ration. In lot I the percentage increases in live weight were good towards the start but started downwards and then recovered greatly on feeding alfalfa hay, the greatest recovery being in the case of the calf started on hay at the younger age. In the body measurements of this group the tendencies were quite similar.

Condition and behavior of calves

Certain results brought about by the rations fed to the animals were most noted in physical characteristics, other than weight and body measurements, and in their body activities and general behavior.

Lot I—milk. In the early part of period III, calf 479 showed a ravenous appetite for shavings and started to eat hair from no. 489 and the faeces were very thin. The animal was quite thin but the muscles were firm. By the beginning of period IV, no. 479 began to lie down considerably. The faeces were

TABLE 11

Percentage increase in live weights and body measurements

PERIOD	GROUP						
	Normal	Lot I		Lot II		Lot III	
		Calf 479	Calf 489	Calf 498	Calf 502	Calf 488	Calf 495
	Increase in live weight						
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
I	34	24	45	35	4	71	46
II	79	63	91	80	22	152	120
III	143	112	155	151	65	265	223
IV	215	120	219	224	66	388	309
V	291	179	271	267		505	421
VI	369	232	349	331		611	
VII	446	249	444	396			
VIII	516	280	524				
IX	575	325					
	Increase in height at withers						
II	7	4	9	4	3	8	8
III	15	10	20	11	8	15	13
IV	21	12	24	17	9	23	25
V	27	9	29	26		31	36
VI	34	20	36	32		40	
VII	39	32	43	37			
VIII	43	33	48				
IX	46	38					
	Increase in depth of chest						
II	12	12	8	13	3	15	9
III	25	23	23	28	20	31	27
IV	35	30	32	41	25	41	39
V	47	38	42	47		50	50
VI	51	47	48	52		65	
VII	64	55	56	59			
VIII	71	54	58				
IX	78	60					
	Increase in width at hooks						
II	12	12	16	19	10	15	16
III	27	23	32	37	13	32	39
IV	40	28	50	47	13	53	58
V	52	37	50	54		75	65
VI	67	51	54	69		91	
VII	76	52	68	76			
VIII	88	60	78				
IX	97	71					

watery and a slate grey in color. The muscles were firm but there was no apparent body fat and the calf started to chew the wooden walls of the pen. In period VI, no. 479 had taken practically all the hair from the back of no. 489 and attempted to cud. This was probably due to the hair and wood eaten.

In period II, calf 489 showed a depraved appetite and in the early part of period III became weak in the knees when led, and down in the front pasterns. Later in the period its gait became stilted and the legs were stiff at the knees and hocks. The skin was very sensitive and twitched when touched, especially along the spinal column. By period V, calf 489 had become quite listless but was erratic to handle.

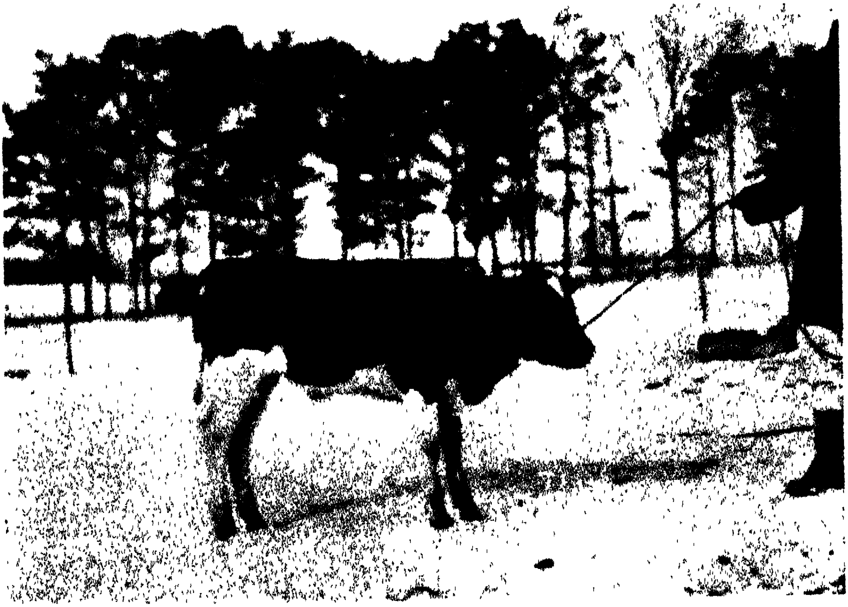

FIG. 1. CALF 489 IN LOT I

This shows the low condition the calf was in after continuous feeding of milk alone for five months.

Within a few hours of the introduction of alfalfa hay to the ration, these calves were chewing the cud and continued to improve from that time on.

Lot II—milk and grain. The calves in this group may be treated separately. In the early part of period III, calf 498 had a good appetite and was in good condition but showed a craving for roughage. It chewed its cud slightly, probably due to eating shavings used as bedding at that time, but they were removed. In the early part of period V the leg joints became swollen and the calf could not stand straight. The knees were bowed outward and forward. The appetite was good but the faeces thin. When this calf was put on hay at the beginning of the sixth period, it began to improve and at the end of period VII it was in good condition.

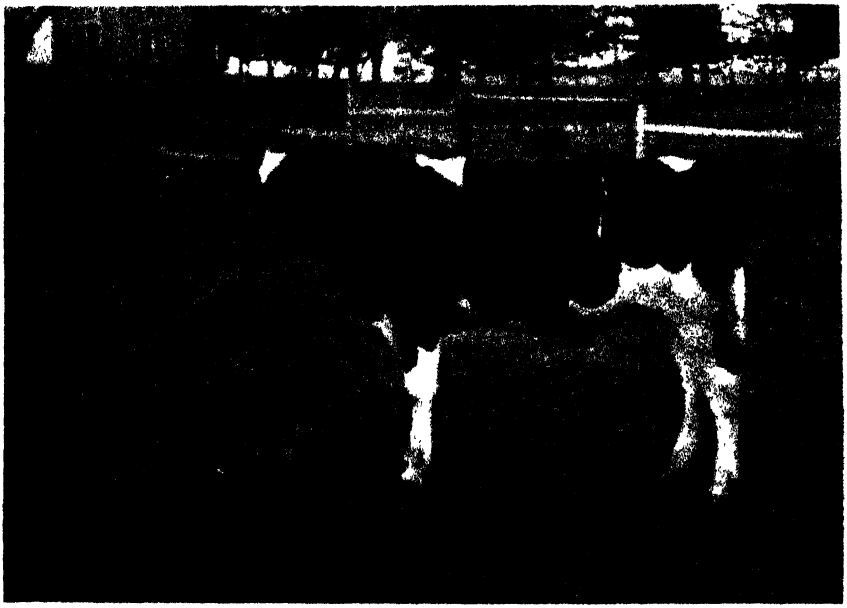

FIG. 2. CALF 489 IN LOT I

A marked improvement is noted in the calf after alfalfa hay has been fed with the milk for three months.

.In the early part of period II, calf 502 began to chew the boards of the pen and to cud to a small extent. At this time it had a good appetite though it was thin and its hair on end. Its vitality kept lowering until in the early part of period V it began to bloat and this eventually became habitual and caused much pain. It became weak in the legs, unable to rise, eventually lost all control of the hind quarters, and died.

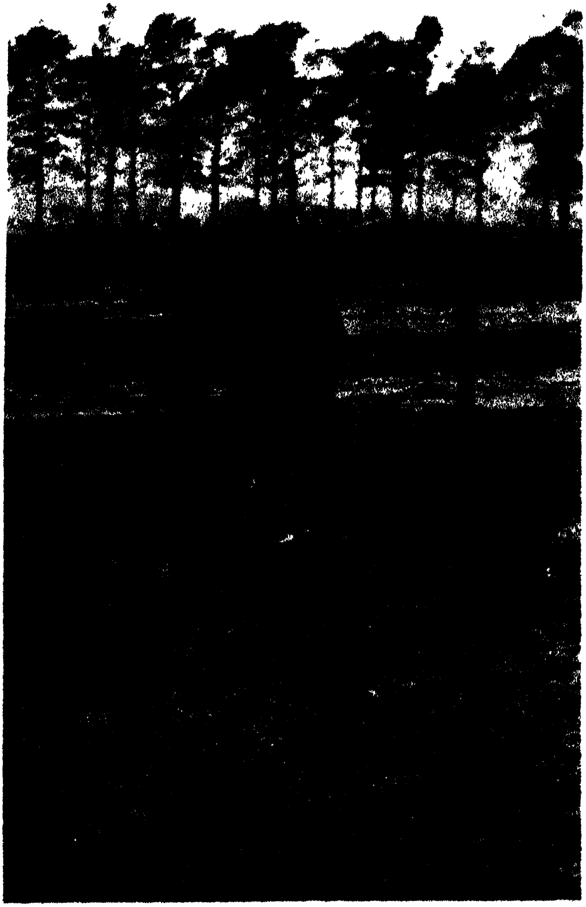

FIG. 3. CALF 498 IN LOT II

Deformation of the bones of the front legs is very evident after the feeding of milk and grain for five months.

Lot III—milk and alfalfa ration. The animals in this group were in good thrifty condition throughout the trial and always maintained a sleek glossy coat. Their faeces were normal though alfalfa hay in this section is sometimes not the best for calf raising as it at times tends to produce scours.

Fig. 4. Calf 498 in Lot II

This shows further bone deformation

Post-mortem examination of calf 502 in lot II

A post-mortem examination was conducted on calf 502 immediately after death, by Drs. B. A. Benbrook and H. D. Bergman of the Veterinary Division.

The stomach. In the stomach as a whole the mucous membrane, folds and papilli were all apparently normal. The musculature of the wall of the rumen was not well developed. The rumen was about one-third undersized and distended with gas. The contents were dry and consisted mainly of oat hulls and some grain. The musculature of the wall of the reticulum was not normally developed, but the compartment approached nearer to normal than did the rumen. The omasum was also undersized. The abomasum was apparently fully developed and contained about a quart of fluid very similar in appearance to bile and contained a sediment of cinders showing that a depraved appetite had caused the calf to eat the cinders used for bedding in the latter part of the experiment. Derangement of the mechanism of the pylorus or hyperacidity of the stomach might explain the presence of the bile-like fluid in the abomasum.

Fig. 5. Calf 498 in Lot II

After alfalfa hay had been added to the ration for two months, the leg bones of this calf came back to normal and it improved in other ways.

The intestine. Catarrhal enteritis was apparent throughout the intestinal tract. The contents of the small intestine were fluid and yellowish in color with small orange-yellow flaky bodies occurring in the fluid. This fluid was apparently largely secreted from the intestinal walls. The contents of the caecum appeared drier than normal. The amount of faeces in the rectum was also small.

The glands. The liver was slightly enlarged, of lighter color than normal, soft, friable, and had a cloudy swelling, due to congestion. The gall bladder was about 4 times normal size and contained about 1½ pints of fluid. The bile was light yellow and flocculent, instead of greenish in color. Catarrhal infection caused swelling that almost entirely closed the opening of the bile duct into the duodenum and pressure on the gall bladder would force only a small amount of fluid into the duodenum. The wall of the gall bladder showed slight hemorrhages.

FIG. 6. CALF 488 IN LOT III

This calf raised on milk and alfalfa was always in good thrifty condition.

The kidneys showed no marked changes but the urine in the bladder was slightly cloudy and there was a slight congestion of the blood vessels in the bladder wall.

A hyperstatic condition existed in the principal lobe and most of the anterior lobes in the lower border of the right side of the lung. The remainder of the lung tissue was edematous.

Hemorrhages occurred in the epicardium and endocardium and were especially evident in the lining of the left ventricle. They were due to infection. The blood vessels in the walls of the gall bladder, in the walls of the bladder and in the mesentery, showed hemorrhages due to infection and weakening of the walls of the blood vessels. The blood was darker than normal and slow to coagulate. This was due to an infection destroying the enzyme thrombrokinase, which enters into the clotting process.

The spleen was enlarged, due to destruction of red blood cells in large quantities as the result of infection. The rapid destruction of red blood cells results in greater production of these cells in the bone marrow and consequently the bone marrow was slightly red instead of being the normal yellow color for a calf of this age.

General. The muscles were slightly yellow and edematous, possibly due to a leakage of blood serum. The knee and ankle joints appeared to be normal in both capsule and bone. The femur of the right hind leg was broken just below the hip joint and appeared to have been broken about two days before death. There was some hemorrhage and laceration about the broken part. The wall of the femur where broken was thinner than in a normal calf of the same age. A section of the radius, just below the left knee was taken for a breaking test.

Cause of death. The immediate cause of death was a non-specific septicaemia arising from organisms normally present in the bovine body. Owing to the weakened condition of the calf these organisms were allowed to develop unduly. The immediate cause of death was this non-specific septicemia which developed owing to the lowered vitality induced by undernutrition.

Breaking test of bone. The bone sample taken from the radius, just below the left knee of calf 502, was given both the breaking and crushing tests by Prof. J. H. Griffith of the Engineering Division.

The sample of bone used was $6\frac{1}{2}$ inches long and $2\frac{9}{16}$ inches at its smallest circumference. The bone had been removed from the body about a day before the breaking and crushing tests were made.

In the breaking test the bone was placed on blocks with a 5-inch span. A ⅝-inch bar laid crosswise sustained the force applied from above. The bone bent, cracked and finally broke with a variable load of from 190 to 640 pounds per square inch. The flexibility of the bone was largely due to the low content of ash constituents.

In the crushing test the weight was applied on the bone 2½ inches from the upper articulation by means of ⅜-inch flat iron bar with rounded edges. The bone crushed with a load of 400 pounds per square inch. The bone was 3 inches in circumference at the crushing point, with the wall of the shaft varying around $\frac{3}{32}$ inch in thickness at the point of crushing. The bone shaft at this point was $1\frac{1}{16}$ inches wide and ⅝ inch thick.

DISCUSSION OF RESULTS

It has been shown that milk as the sole ration for calves is unsuitable and that a ration of milk with a grain mixture of corn, oats, wheat bran and old-process linseed oil meal is even less valuable, while the addition of alfalfa hay to these two rations will render them quite well adapted to the needs of the growing calf. An explanation of the differences in the value of the rations is by no means easy.

The first point to note is the amount of nutrients consumed by the calves. From the feed data and the analyses given by Henry and Morrison (48) this information was obtained and from the same source the actual requirements of the calves were determined as in paper V of this series. The percentage variation of the amount of nutrients consumed from the requirements of the calves were then obtained for each thirty-day period.

Lack of bulk

To prevent confusion it should be stated that there is a distinction between the bulk of a feed and the dry matter it contains. The dry matter is simply the sum of the water-free constituents present, while the bulk of a ration is indicated by the weight of the feed which will fill a given unit of volume. Thus 100 pounds

TABLE 42

Percentage increase in nutrients provided in addition to requirements

PERIOD	LOT I						LOT II						LOT III					
	Calf 479			Calf 489			Calf 498			Calf 502			Calf 488			Calf 495		
	D. M.	D. N.		D. M.	D. N.		D. M	D N.		D. M.	D N.		D. M.	D. N.		D. M.	D. N.	
		Cr. P.	C. E.		Cr P.	C. E.		Cr P.	C. E.		Cr P.	C E.		Cr. P.	C. E.		Cr. P.	C. E.
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
I	31	44	50	3	12	33	16	26	33	−1	9	12	7	14	20	47	88	57
II	32	43	50	10	17	14	4	8	14	39	32	47	47	111	47	86	187	82
III	8	15	21	−31	5	11	29	14	27	58	39	53	47	143	26	36	253	65
IV	−30	5	12	−51	−17	−10	46	15	31	71	39	58	6	307	41	25	295	64
V	−29	8	13	−62	−22	−28	1	9	25				10	446	41	−4	364	24
VI	−49	−13	−6	−52	69	−21	14	114	28				10	483	41			
VII	−57	−12	−18	−28	122	4	−5	165	22									
VIII	−23	151	18	−24	283	1												
IX	−20	218	17															

D. M., Dry matter.
D. N., Digestible nutrients.
Cr. P., Crude protein.
C. E., Carbohydrate equivalent.

of corn and 100 pounds of alfalfa hay are of the same weight but the corn occupies considerably less space than the hay and so the alfalfa hay is classed as a bulky feed.

The calves in lot I had an oversupply of digestible nutrients until the end of period V in the case of calf 479 and until the end of period III with calf 489. At those times the supplies of nutrients became deficient and continued to be so until alfalfa was added to the ration, even though the calves were receiving all the milk they could handle. The excess of nutrients that was at first supplied decreased gradually while the excess of dry matter decreased more rapidly and at an early stage in the experiment too little dry matter was being allowed, when milk alone was fed. As alfalfa was added to the ration the deficiency in the supply of dry matter gradually decreased and when the calves had come back into good condition the dry matter deficiency was rapidly disappearing. In other words, the bulky hay apparently aided in the recovery of the calves, in lot I, due to the fact that the additional bulk helped to expand the rumen and other portions of the digestive tract and render the calves capable of handling the nutrients with which they were provided. This necessary bulk was not present when the sole ration of the calves was milk.

It should be noted that calf 479 was always behind normal in live weight increase, but after alfalfa was added to the ration it came nearer to normal. Calf 489 was above normal at the start but decreased relatively in live weight until alfalfa was added in period VI when it started to increase rapidly in live weight and at and end of the trial was above normal.

In lot II where milk and grain were fed there were only a few times at which the supply of dry matter was deficient. There was a slight deficiency in the last period for calf 498 and in the first period for calf 502. The dry matter these calves received was not of a bulky character and calf 502 died in period V, although it had an ample supply of nutrients throughout the trial.

In the case of calf 498 the fair excess of nutrients available at the start decreased irregularly until in period V there was an excess of only 1 per cent of dry matter in the ration. Alfalfa hay was then added and there was a great increase in digestible crude protein and also in other nutrients. The amount of dry matter was also increased though it went below the requirements in the last period, perhaps due to increasing capacity on the part of the calf.

The calf 502 was always below normal in live weight increase while the calf 498 maintained a good rate of increase for a time but dropped below normal in period V and then on the addition of alfalfa hay increased in live weight in a manner more nearly normal.

Evidently the addition of the grain mixture to the milk ration not only did not provide sufficient bulk but it had other bad effects as the calves did not do as well as those on milk alone. The addition of a bulky feed produced good results, however.

The calves in lot III were provided with plenty of bulk and, with but one exception, with plenty of dry matter. as they had a ration of milk and alfalfa hay from the start. In the rate of live weight increase they kept well ahead of the normal calves.

Thus far the data presented would indicate that the presence of sufficient bulk in the ration is absolutely necessary for young growing calves.

Quality of ash

The quantity and the quality of the ash fed in the ration to animals has a considerable influence on the ultimate benefit of the feed to the animal and one of the important factors to note is the calcium-magnesium ratio in the rations of the various groups. For the determination of this ratio the figures on the lime and magnesia contents of feeds given by Henry and Morrison (48) are used.

In considering the ratio of the lime (CaO) to magnesia (MgO) in the rations, the lime content is taken as unity. It was found in the case of lot I that the ratio was 1:0.1, or in other words, there was 10 times as much lime as magnesia in the ration when milk alone was fed. When alfalfa hay was added the ratio changed to 1:0.2 or 1:0.3, or in other words, there was 5 to 3 times as much lime as magnesia. In lot III the ratios found were very similar in some respects to those in the later periods for lot I, the ratio being generally 1:0.2 or 1:0.3.

With lot II the lime-magnesia ratio changed to 1:0.4 in the case of calf 502 just before its death and to 1:0.6 for calf 498 in period V. At this time calf 498 cut its grain consumption considerably and in the next period the ratio was 1:0.4, while in the following period it was back to 1:0.3 on the addition of alfalfa hay to the ration.

These results appear to be in accord with those of Forbes (43). When an excess of magnesium in proportion to the calcium is provided, the excess of magnesium is removed by a counteractive liberation of calcium from the tissues, especially the bone, and this may lead to malformation of the bones, especially of the legs. Such malformations of the legs were quite noticeable in the case of calf 498 before alfalfa was added to the ration (figs. 3 and 4), but on its addition the bones of the legs showed marked improvement (fig. 5). This would indicate that a ration of milk and the grains used is not only deficient in bulk but also lacks the proper balance of lime and magnesia in the ash and is even less suited for growing calves than a ration of milk alone.

TABLE 43

Lime and magnesia per 1000 pounds of feed. After Henry and Morrison (48)

	FEED					
	Milk*	Corn	Oats	Bran	Oil meal	Alfalfa hay
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
Lime	1.8	0.2	1.4	0.9	5.1	19.5
Magnesia	0.2	1.8	2.0	7.3	8.1	5.9

* Taken to be the same as in skim milk.

Vitamine supply

Another very important factor so far as the nutrition of the calves in this study is concerned is the supply of vitamines, as there is a possibility that the calves might not have been provided with sufficient of them.

TABLE 44

Lime-magnesia ratio in rations

PERIOD	LOT I						LOT II						LOT III					
	Lime		Magnesia		Ratio		Lime		Magnesia		Ratio		Lime		Magnesia		Ratio	
	Calf 479	Calf 489	Calf 479	Calf 489	Calf 479	Calf 489	Calf 498	Calf 502	Calf 498	Calf 502	Calf 498	Calf 502	Calf 488	Calf 495	Calf 488	Calf 495	Calf 488	Calf 495
I	0 63	0 60	0 07	0 07	0 1	0 1	0 39	0 39	0 04	0 04	0 1	0 1	0 54	0 73	0 06	0 11	0 1	0 2
II	0 81	0 88	0 09	0 10	0 1	0 1	0 44	0 49	0 06	0 09	0 1	0 2	1 36	1 51	0 25	0 30	0 2	0 2
III	0 87	1 08	0 10	0 12	0 1	0 1	0 53	0 53	0 15	0 17	0 3	0 3	2 23	2 68	0 52	0 66	0 2	0 2
IV	0 97	1 13	0 11	0 13	0 1	0 1	0 57	0 56	0 28	0 25	0 5	0 4	4 40	4 09	1 18	1 08	0 3	0 3
V	1 13	1 13	0 13	0 13	0 1	0 1	0 60		0 37		0 6		5 96	5 10	1 65	1 39	0 3	0 3
VI	1 13	2 01	0 13	0 27	0 1	0 1	1 72		0 62		0 4		6 91		1 94		0 3	
VII	1 13	4 04	0 13	1 01	0 1	0 3	2 64		0 81		0 3							
VIII	2 81	5 11	0 64	1 33	0 2	0 3												
IX	3 49		0 84		0 2													

In considering all lots it may be said that butterfat is still regarded as the most important source of fat-soluble A and this is clearly demonstrated in the compilation of Blunt and Wang (34). It may be allowed therefore that the calves had sufficient of this vitamine.

Milk is not too rich in water-soluble B according to Osborne, Mendel, Ferry and Wakeman (50) but there should have been sufficient of it present to carry the various groups in good condition. It is perhaps also true that the water-soluble C present may have been sufficient according to Chick, Hume, Shelton and Smith (37 and 38).

When the other feeds in addition to milk are considered it is noted that the yellow corn fed to lot II contained fat-soluble A according to Steenbock and Boutwell (53), although this was already present in the milk. The cereals provided would also furnish the calves with additional water-soluble B according to Osborne and Mendel (49) but the bran would be of no value in this respect according to Briggs (32). The oats and other grains would not add any water-soluble C according to Harden and Zilva (44). As a consequence, therefore, lot II was probably provided with more fat-soluble A and water-soluble B than lot I but they did not do as well and so the deficiencies of milk as the ration of lot I cannot be attributed entirely to the lack of these vitamines.

In the third lot alfalfa hay was fed in addition to the milk and these calves did well and the animals in lots I and II, which had reached a very low degree of vitality, recovered when alfalfa was fed. Alfalfa contains fat-soluble A according to Steenbock and Boutwell (53) but this was already present in the milk. Water-soluble B occurs in considerable amounts in immature alfalfa but in less amounts when it is mature as has been stated by Osborne and Mendel (49) and undoubtedly much of this is lost in haymaking and storage and so it is doubtful if the alfalfa improved the ration so far as water-soluble B is concerned.

Alfalfa also contains water-soluble C but Chick, Hume, Shelton and Smith (38) and Delf and Shelton (40) state that when the living tissues are disorganized by drying the water-soluble C is destroyed. Consequently the alfalfa hay would apparently be of little value to the calves as a source of this vitamine. The alfalfa hay was the feed which produced the greatest growth and brought the calves that were below normal back to normal and yet it would appear that this was not entirely due to any vitamines which it might supply.

From the results obtained in this work it would appear that though milk is a poor ration for calves after they are a few weeks old, the addition of a grain mixture such as that used will give even poorer results. On the other hand, the feeding of alfalfa gave good results.

It would appear that the benefits of alfalfa do not lie entirely in the provision of more nutrients or in improving the vitamine supply. The alfalfa provides bulk which keeps the digestive tract of the calf distended and in proper condition for the handling of feed. The grain used produced bad effects by increasing the relative amount of magnesium as compared with calcium in the ration.

SUMMARY

From the work reported here it would appear that the following deductions are possible:

1. Milk though a suitable ration for young calves cannot maintain ruminants indefinitely.

2. The addition of a grain mixture of corn, oats, bran and oil meal to a ration consisting solely of milk impairs the growth of the calves and leads to death even more rapidly than a ration of milk only.

3. The cause of the earlier death on the addition of the grains is probably due to the depletion of the body stores of calcium due to the fact that the grains contain more magnesium than calcium and calcium must consequently be drawn from the body, especially the bones, to take care of this excess of magnesium.

4. The addition of alfalfa hay to a ration of milk or of milk, corn, oats, bran and oil meal will bring back to good growing condition animals which have fallen to a low place of nutrition on the rations mentioned.

5. Milk and alfalfa hay can be used to grow out calves satisfactorily.

6. The beneficial effects of the alfalfa hay are apparently not due absolutely to the nutrients it supplies as an abundance of nutrients had been provided in the other experimental rations.

7. It is apparently not probable that the alfalfa hay adds in appreciable amounts vitamines which might have been absent from the other rations used.

8. Where alfalfa is added to a ration of milk and the grain mixture used, it would appear that part of the beneficial effect of the alfalfa is due to the fact that it increases the calcium content as compared to the magnesium content of the ration and thus conserves the calcium stores of the body.

9. The main advantage derived from the alfalfa hay seems to be due to the fact that this feed, being bulky in character, helps to distend the digestive tract of the calf and so renders proper digestion possible.

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DAIRY NOTES

Pennsylvania. J. R. Dawson, who has been extension dairyman at the Pennsylvania State College, has recently resigned to accept a position with the United States Department of Agriculture.

Indiana. R. D. Canan, who has been field man for the American Jersey Cattle Club at Indianapolis, has recently resigned to take up dairy extension work in Indiana.

Tennessee. J. J. Hooper, chairman of the Committee on Students Dairy Cattle Judging Contests, Southern Division American Dairy Science Association, reports the establishment of a dairy cattle judging contest for the Agricultural Colleges of the South to be held in connection with the Tri-State Fair at Memphis, Monday, September 24, 1923.

Rules and regulations to govern the contest will be the same as those governing the National Contest. Premiums will consist of handsome trophies for (1) team ranking highest in all breeds, (2) highest on Jerseys, (3) highest on Holsteins, (4) highest on Guernseys. Gold medals will be awarded the individuals ranking highest in these four places.

ANNUAL MEETING OF THE SOUTHERN DIVISION, AMERICAN DAIRY SCIENCE ASSOCIATION

The second annual meeting of the Southern Division, American Dairy Science Association was held at Chisca Hotel, Memphis, Tenn., February 7, 1923, and was called to order by President C. W. Holdaway of Virginia at 2:00 p.m., and the minutes of the previous meeting were read and accepted.

Professor Holdaway in his address briefly outlined the history of the association, the development of its divisions, and the particular problems confronting the Southern Division workers, stressing the need of specialized dairy instruction in southern schools.

A discussion of stock judging was led by Dan T. Gray, director of Animal Industry, Auburn, Ala., who emphasized the need of standardization of methods and the value of pedigrees. On motion of J. A. Gamble, presiding officer E. S. Good was instructed to appoint a committee to study this matter and report its findings at the meeting next year.

J. H. McClain dealt briefly with the dairy problems peculiar to the South, especially the production of quality butter against which no discrimination will be made in northern markets. He urged the importance of increased production through better feeding and breeding, and suggested research work to determine just how impotency of sires brought down from the North can be overcome.

Stanley Combs proposed the appointment of a committee to study the influence of feeds on butter texture, and suggested a combination of cottonseed meal and soybeans to overcome common defects of southern butter. He further emphasized the need for increased consumption of milk by children of the South and the importance of home-mixed vs. ready-mixed rations for dairy cattle.

For better marketing Mr. Combs suggested that some commission house be induced to specialize in handling southern butter. Professor Dvorachek of Arkansas cited that state's experience in securing better butter through a system of cream grading whereby a premium was paid for the better grades of cream. C. A. Hutton of Tennessee endorsed this system and said that when farmers are convinced that southern butter can be good and will take care in handling their milk and cream, good butter will automatically result.

R. S. Curtis of Raleigh, N. C., then summarized his findings on the coördination of teaching, experimental and extension work in the South. A. O. Jamison discussed rational milk control, pointing out that pasteurization is a godsend to the dairy industry. Factors affecting the official butterfat tests of cows were presented by C. E. Wylie and aroused considerable comment. This paper is found in full on page 292 of this issue.

Results of experimental work to note the effect of cottonseed meal upon the growth and reproduction of cows were given by Professor Combs. This paper will be submitted for publication in a later issue.

C. E. Wylie, chairman of the Committee on Feeding, presented a report recommending (1) a careful study of the pasture situation and the introduction and development of the best pasture grasses for southern conditions, (2) experiments to determine the value of silage in the South, (3) attention to proper housing and management of dairy cattle, (4) further study of the relation of feeds to production of good butter.

"Dairy Statistics of the Southern States and Their Significance to the Dairy Industry of the United States," was the topic of a report read by R. C. Potts of the Bureau of Markets, United States Department of Agriculture; and G. P. Warber, Virginia Polytechnic Institute, Blacksburg, Va., presented a paper on "Rational Control of Fluid Milk Supply of Cities."

By-laws governing the Southern Division were adopted, and resolutions passed recognizing the importance of livestock to profitable southern agriculture both through increased production due to restoration of fertility to the soil and through direct revenue from products sold; and hearty support of efforts to solve southern probems of production and marketing was urged.

The following officers were elected: Chairman, C. E. Wylie, Knoxville, Tennessee; Vice-chairman, J. P. LaMaster, Clemson College, South Carolina; Secretary, J. A. Gamble, College Park, Maryland.

THE WORLD'S DAIRY CONGRESS

H. E. VAN NORMAN
President, World's Dairy Congress Association, Washington, D. C.

Received for publication July 7, 1923

The World's Dairy Congress is to be a conference of international representatives of the dairy industry, its related sciences and public health and social welfare agencies. Its purpose is to bring together the forward-looking leaders who are shaping the trend of science and industry; to exchange the newer knowledge of the science and practices of dairying and allied activities; to study the economic forces which influence domestic and international commerce in dairy animals, products and equipment; to discuss methods of disease prevention and of regulating and controlling the sanitation and standards of dairy products; to consider the influence of a wise use of milk and its products on national health and the vital importance of the part which they play in human physical and mental development.

Acting under the authorization of a law of March 3, 1921, the President of the United States has invited all Governments to send representatives to the sessions and, in addition, the World's Dairy Congress Association has invited institutions, firms and associations of this and other lands to send delegates and has asked the Governors of all the States of the Union to attend the sessions and appoint commissions to represent their dairy and allied interests. The Congress will hold its opening sessions at Washington, D. C., on October 2 and 3, adjourn to Philadelphia, Pa., for October 4 and continue at Syracuse, N. Y., from October 5 to 10.

The dairy industry is passing through a transitional period. The war and the after-war conditions have forced it into a world readjustment. The shift in international dairy trade and the struggle to regain pre-war business have made the problems of the industry world problems. While damming up the normal flow of international scientific information, the war resulted in many new discoveries, particularly in the principles of human nutrition. The World's Dairy Congress offers an opportunity to bring these facts to the attention of all nations through discussion by scientists, welfare workers and business men.

Progress in all countries and in all industries is stimulated by the exchange of experience and information. Attendants will derive much benefit from personal contact with the leaders from other nations, whose problems are similar to their own, as well as by attending the formal sessions. Each country has something to contribute, each has something to gain.

The men in all countries, who have made outstanding contributions to the science or business methods of dairying or to public health work through the use of dairy products, have been invited to participate in the program of the World's Dairy Congress. Acceptances indicate that the most pressing problems in research, regulation, economics and use of dairy products, now confronting the industry and society, will be thoroughly considered in this program and that the most important achievements of the last ten years will be presented for the service of the whole world.

The program for the World's Dairy Congress will include about two hundred papers well distributed among the various branches of the industry. Since it will be impossible to present all of these papers to the entire Congress in the time available, it will be necessary to hold at least four simultaneous sessions daily. The two days in Washington will be devoted to general sessions at which will be discussed questions of general interest, particularly international trade and the general world development of the industry and its relation to human welfare.

Abstracts of all papers submitted early enough will be available to delegates in English, French, German or Spanish at the time of registration. Discussions may be in any one of the four languages at the Congress sessions and interpreters will translate what is said. The program has been arranged to interest the following groups:

I. Research and Education—teachers, investigators, officials, engineers and other technical men, interested in the solution of dairy problems.

II. Industry and Economics—men engaged in breeding dairy cattle and in producing, manufacturing, exporting, importing, storing and distributing dairy products and equipment.

III. Regulation and Control—national, state, municipal and private officials, concerned with standards, adulteration, sanitation and animal disease control.

IV. National Health—public health and nutrition workers, philanthropists, social welfare workers, and students of the influence of diet on the health and vigor of all nations.

At Washington, D. C., foreign delegates will be formally received by Government officials and greeted by American dairy scientists and leaders. The opening sessions will include discussions of some of the most interesting papers of the program, especially those dealing with the broadest international topics—scientific, economic and humanitarian—with addresses by men of world-wide reputation. A reception, a dinner and visits to research laboratories, public buildings and historic places will be a few of the activities in this city.

At Philadelphia, Pa., a full day will be devoted to a complete display by the National Dairy Council of its methods and results in promoting health by the proper use of milk and its products. An opportunity will be given to visit manufacturing and milk-distributing plants and places of historic interest. In the evening there will be a banquet with speakers of international reputation and an original program by the National Dairy Council.

At Syracuse, papers relative to particular subjects will be presented at group meetings each forenoon. The papers will be grouped, as far as possible, to bring together those on related subjects. Thus, there will be one session devoted to breeding, one to feeding problems, one or more to the chemistry and bacteriology of cheese, at least two to coöperative marketing problems, one or more to transportation and other problems of the city milk dealer, and many other similar groups.

The program has been planned to present the status of the dairy industry of the world as it exists today. The great diversity of subjects, which must be included to cover all the varied ramifications produced by the rapid development of the last few decades, will require two radical departures from the programs of preceding congresses.

An entirely new section will be devoted to the part played by milk and its products in promoting the health of the people. Two phases of this subject will be presented. One of these will consist of the recent advances in the science of nutrition, particularly where that science deals with the peculiar characteristics which make milk important in promoting growth and vigor. The other phase will consist of ways and means of conveying this information to the public.

The second departure from preceding programs will consist in the attention to be devoted to national and international economic and trade problems. One session will be devoted to a discussion by prominent economists of questions of international trade in dairy products and the relation of business conditions in general to the dairy industry. The program will include numerous papers on the technical questions involved in the manufacture of dairy products. It will also give particular attention to questions interesting those who produce, buy, sell and manufacture dairy products and equipment used in the dairy industry and to economic questions connected with the movement of dairy products in international trade and involved in the relation of world conditions to prices.

Because of the very general interest, considerable time will be devoted to papers on coöperative organizations, particularly organizations formed by producers to sell products. These papers will deal largely with the principles which are essential to success and the defects which have been the cause of friction. Delegates from countries in which coöperative marketing has been highly developed will take part in this section of the program.

The problems of the city milk dealers will be discussed in a series of papers by authorities from different parts of the world on transportation, distribution and other pertinent questions, such as the development of bulk transportation of dairy products by tank car and truck. The adjustment of prices and the factors which determine cost of production will be considered. The manufacturers of dairy equipment will be interested in a group of papers on the selection of materials for dairy machinery and utensils and the standardization of equipment and containers.

The part of the program devoted to Regulation and Control will include discussions of the administration of laws, safeguarding the producer and the consumer of milk and milk products from fraud and infection by disease bacteria. Measures used by the industry itself for the improvement of the milk supply will be considered.

In general, papers will deal with the broader aspects of dairy problems; but technical papers of special interest to the investigator and teacher will be added. A general outline of the system of agricultural education and investigation in the United States will be presented and detailed attention will be given to methods of dairy education by authoritative speakers from the leading dairy countries.

In the section on Research and Education, will be included a collection of papers on the physiology of milk secretion and the chemistry of milk, summarizing the world's knowledge of these subjects. A number of the most active of the investigators of these problems will take part. Some problems of the breeder will be presented by prominent investigators. The diseases of dairy cattle will be considered in a symposium on the more serious ones. A number of prominent bacteriologists will discuss the group of bacteria of importance in dairying.

A COMPARISON OF EARLY, MEDIUM AND LATE MATURING VARIETIES OF SILAGE CORN FOR MILK PRODUCTION

REPORT OF SECOND FEEDING TRIAL

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Received for publication April 15, 1923

The results of the first trial having been reported (1), interest in the work seems to warrant the publication of the data obtained in the second year, together with averages of both. A third trial is being run on the same plan. As stated in the first paper, the problem of the northern dairyman is not one of date of harvesting, or proper stage of maturity for a given variety, but the selection of a type or variety which will make the most milk per acre. It seems to be accepted that steers will not make the most profitable gains on immature silage, but for milk production this is an open question.

Chemical analysis easily establishes that 100 pounds of mature corn silage contains more total nutrients than the same weight of silage made from immature corn. Also several careful investigations, notably that of the Indiana Experiment Station (2), have given us data on the rate of increase in dry matter and the various constituents up to maturity for a given variety or type; so that so far as date of harvest for maximum yield of dry matter is concerned, the question is settled.

However, nine years of field tests at this station have proven that large growing, late maturing varieties will produce more dry matter per acre, even when harvested very immature, than varieties that mature in this region. The question then arises: "Is the greater theoretical feeding value *per ton* of the early types, sufficient to offset the greater yield of dry matter *per acre* of the late types?" It is this question that these feeding trials are designed to answer.

EXPERIMENTAL PROCEDURE

The second feeding trial was carried on in the same manner as the first, there being four cows in each group, with the exception of the medium, which includes only three. All animals were fed the same amounts of silage (50 pounds, except one animal in each of the Early and Late Groups) the grain being varied to maintain constant weight. Six pounds of hay per cow per day were fed this year instead of four as in the first trial. This hay was purchased on the market and was a mixed grade, largely timothy. All feeds were sampled and analyzed in the same manner as described in the previous paper. No unusual conditions arose during the actual experimental period of one hundred days. The preliminary feeding started on January 11, with regular herd silage. Experimental silage was started January 31, and the one hundred day period was begun February 20.

Notes on animals and feeding

As far as possible the same cows were used as in the previous trial, except that they were changed to other groups. Thus Fusion, Colony and V. J. Storrs were changed from late to early. Likewise Pansy and Fruition here in the late group were previously in the early, while Storrs Robin 2d came from the medium group of last year to the late of this. Simple alone remained in her original group—medium. Grades 257, 258, 259, and 260 were purchased as springers a short time prior to this trial for this specific purpose.

Fusion was in quite good condition when she calved and because of her milking tendency it was necessary to allow a considerable loss in weight (56 pounds). On the whole, the individuals balanced satisfactorily. The weights were controlled as described in the previous report.

All cows except V. J. Storrs and Storrs Robin 2d were fed 50 pounds of silage daily. These two were fed 40 pounds daily. Fruition, in the late group, was off feed for a few days early in the experiment. All cows ate within less than a pound per day of their silage allowance for the one hundred days. The hay was eaten clean from one feeding at noon. By feeding grain to keep the weight constant, the appetite of all cows remained remarkably good, no trouble resulting after the experiment was under way. The grain ration as before consisted of three parts yellow corn meal (no. 2), three parts wheat bran, and two parts cottonseed meal (36 per cent).

The medium group in both the first and present trials was not balanced as closely in weight and milk production with the other two groups as would be desirable. Emphasis was placed on the two extremes and the remaining animals were placed in the medium silage. In the third trial the medium (Leaming) silage has an equal opportunity.

THE TYPES OF SILAGE CORN

The same three varieties were used as in the first trial, these being chosen as best representing the three types we desired to compare. They were all planted on the same day, May 26, 1921, in adjacent plots and harvested on three consecutive days before frost, September 16 to 20. They were grown in a twenty-two acre field regularly devoted to raising crops for the dairy herd. To answer questions regarding these varieties the following data is given:

Early type. A strain of "Pride of the North," originally secured from Cornell Station and grown at Storrs for twelve years. Ripens at Storrs in one hundred and thirty days.

Medium type. A strain of "Leaming," seed for which is secured each year from the same grower in Clark County, Ohio. Ripens in one hundred and forty days at Storrs. Our season is seldom long enough for it to ripen.

Late type. "Eureka," a very large growing white corn, seed for which is secured each year from the same source in Virginia. Has seldom reached dent stage at Storrs.

Table 1 gives the data on the corn as grown in 1921 for this trial, and table 2 the average results obtained for these varieties on the test plots over a period of years.

TABLE 1

Data on silage as harvested—second trial 1922 (corn grown in 1921)

All planted and harvested at the same time

TYPE	STAGE OF MATURITY	PER CENT OF TOTAL GREEN WEIGHT							ACTUAL YIELDS PER ACRE AS GROWN FOR FEEDING TRIAL
		Water	Dry matter	Ash	Crude protein	Crude fiber	N F E	Fat	
									tons
Early.. .	Ripe, husks drying	66.19	33.81	0.95	2.60	5.56	23.41	1.00	12.4
Medium	Soft dough	73.77	26.23	1.07	1.71	5.93	16.89	0.63	16.4
Late	Early milk	77.29	22.71	1.00	1.26	6.66	13.50	0.29	21.2

All the corn grown in 1921 for this trial (table 1) shows less water than the average composition (table 2). The season was longer and the silos were not filled as early as usual. Note that they all show greater maturity.

TABLE 2

Averages of several tests on these varieties

All planted and harvested at the same time

TYPE	STAGE OF MATURITY	WATER	YIELD PER ACRE	
			Green weights	Dry matter
		per cent	*pounds*	*pounds*
Early..	Hard dough	73.80	24,774 (12.4T.)	6491
Medium.	Soft dough	78.09	32,947 (16.5T.)	7218
Late..................	Kernels forming	80.16	40,648 (20.3T.)	8064

TABLE 3

Analysis of feeds as fed—second trial, 1922

	WATER	DRY MATTER	ASH	CRUDE PROTEIN	CRUDE FIBER	N.F.E.	FAT
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Timothy hay	3.02	96.98	4.75	6.81	28.84	53.81	2.77
Grain	8.60	91.40	4.60	17.44	8.09	56.36	4.97
Early silage	68.36	31.63	1.26	2.50	6.59	20.31	0.96
Medium silage	75.09	24.90	1.23	1.75	5.91	15.30	0.69
Late silage	79.76	20.23	1.14	1.41	6.35	10.61	0.49

Grain is not so high in water this year. Corn was kiln-dried on day of grinding and mixing.

The per cent of water is greater in the silage than in the green corn as cut in, due to the fermentation, one product of which is water.

TABLE 4

Data concerning experimental cows—second trial, 1922

One hundred days—February 20 to May 30—experimental.
Forty-one days—January 11 to February 20—preliminary.

	BREED	AGE	CALVED	CONCEIVED	INITIAL WEIGHT	FINAL WEIGHT	AVERAGE WEIGHT	EXTREME VARIATION FROM INITIAL WEIGHT	DATE OF EXTREME VARIATIONS	GAIN OR LOSS IN WEIGHT
Early group										
		years								
Fusion	P. B. Hol.	5	12/22/21	5/18/22	1405	1349	1378	1344	5/25	−56
258	Gr. Hol.	10	11/26/21	3/19/22	1127	1120	1135	1149	4/9	− 7
Colony	Gr. Hol.	5	12/17/21	3/ 3/22	1117	1153	1144	1159	4/17	+36
V. J. Storrs	P. B. Jer.	7	11/ 6/21		903	896	906	913	4/2	− 7
Medium group										
257	Gr. Hol.	9	11/20/21	3/31/22	1001	976	990	974	5/29	−25
259	Gr. Hol.	7	12/ 4/21	3/12/22	1058	1087	1077	1087	5/30	+29
Simple	P. B. Guer.	10	11/ 2/21	3/ 4/22	1024	986	1010	981	5/26	−38
Late group										
Pansy	P. B. Hol.	8	1/ 5/22	5/20/22	1090	1131	1113	1131	5/30	+41
Fruition	P. B. Hol.	5	1/17/22	3/29/22	1192	1171	1169	1143	3/31	−21
260	Gr. Hol.	6	12/31/21	2/27/22	1095	1097	1096	1080	5/6	+ 2
S. Robin 2d	P. B. Jer.	9	11/19/21	1/27/22	915	901	908	890	5/22	−14

TABLE 5

Average daily consumption of feed per cow—second trial, 1922

GROUP	GRAIN			SILAGE			HAY			TOTAL DRY MATTER
	Amount	Protein	Dry matter	Amount	Protein	Dry matter	Amount	Protein	Dry matter	
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
Early	7.313	1.271	6.684	47.468	1.186	15.015	5.997	0.408	5.816	27.515
Medium	7.161	1.245	6.546	49.885	0.875	12.422	5.994	0.408	5.813	24.781
Late	8.622	1.499	7.880	46.696	0.663	9.449	6.000	0.408	5.819	23.148

TABLE 6

Average daily production per cow—second trial, 1922

GROUP	MILK	FAT	TOTAL SOLIDS	MILK COMPUTED TO 12 PER CENT SOLIDS	TOTAL SOLIDS IN MILK
	pounds	*pounds*	*pounds*	*pounds*	*per cent*
Early	25.546	0.8929	3.0406	25.354	11.91
Medium	20 728	0.8100	2.6075	21.730	12.58
Late	22.327	0 8301	2.6942	22.457	12.07

RESULTS FOR BOTH TRIALS

Both trials were run on the same plan—that is, silage was fed in the same quantity for each group. In order to average the results of both, the data for the first trial has been arranged in the same manner as in Table 7.

Tables 7 and 8 give a chance for comparison of the two years results. They are consistent. The less dry matter required for 100 pounds of milk in the first trial is partly due to the larger yields of milk the first year. The yields for one hundred days for the two years per cow follow: Early—2828.2 pounds in 1921, and 2554.6 pounds in 1922; medium—2293.8 pounds in 1921, and 2072.8 pounds in 1922; late—2920.6 pounds in 1921, and 2232.7 pounds in 1922. The difference in yields was due mostly to the particular character of the cows, the grades which were purchased not being in so good condition at calving time.

TABLE 7

Pounds feed and dry matter consumed—second trial, 1922

Per 100 pounds of milk

GROUP	SEPARATE FEEDS—MILK AS PRODUCED						TOTAL DRY MATTER PER 100 POUNDS MILK		
	Silage		Grain		Hay		As produced	Milk of 12 per cent solids content (1)	With adjustments for weight and 12 per cent milk (2)
	Total	Dry matter	Total	Dry matter	Total	Dry matter			
Early	185.81	66.20	28.941	26.452	23.475	22.766	115.42	116.29	116.29
Medium	240.66	59.92	34.280	31.330	28.920	28.050	119.30	113.80	116.71
Late	209.15	43.31	39.597	36.190	26.870	26.060	104.56	103.95	105.19

(1) The milk varied slightly in total solids, with the three groups. The total solids produced is used and the dry matter in feed is computed in this column to the amount that would have been required for 100 pounds of 12 per cent milk in each group.

(2) There were differences among the average weights by groups, the Early weighing most, the Late next and the Medium least. Coefficients of digestibility from Henry and Morrison (table 2) were applied to the analyses of feeds as fed (table 3, this manuscript), maintenance requirements were calculated from the Henry-Morrison modified standards and expressed in terms of dry matter. These adjustments, together with those for milk quality, were applied in computing the last column. Thus the three groups are placed on as uniform a basis as possible.

TABLE 8

Pounds of feed and dry matter consumed—first trial, 1921

Per 100 pounds of milk

GROUP	SEPARATE FEEDS—MILK AS PRODUCED						TOTAL DRY MATTER PER 100 POUNDS OF MILK		
	Silage		Grain		Hay		As produced	Milk of 12 per cent solids content	With adjustments for weight and 12 per cent milk
	Total	Dry matter	Total	Dry matter	Total	Dry matter			
Early	159.00	40.93	35.405	31.27	14.14	13.54	85.74	81.33	81.33
Medium	199.01	50.09	35.816	31.64	17.40	16.66	98.39	85.74	90.06
Late	155.92	30.30	39.780	35.14	13.70	13.12	78.56	76.52	76.79

The yields per pound of grain fed are illustrated as follows: early—2.84 pounds in 1921, and 3.49 pounds in 1922; medium—2.76 pounds in 1921, and 2.89 pounds in 1922; late—2.54 pounds in 1921, and 2.59 pounds in 1922. This milk increase per unit of grain is greatest in the early group. It should be recalled that the silage in 1922 was more mature for each variety and more especially the early, which contained 5.9 pounds less water per 100 pounds silage in 1922. Also the additional amount of hay (200 pounds per cow) must have effected a saving in grain. Had the yields of milk for the two years been the same, the value of the additional hay and slightly richer silage would doubtless have been more apparent in the medium and late groups. In 1922, with the lower production, a greater percentage of the total feed consumed was naturally used in maintenance.

TABLE 9

First and second trials combined to show relative efficiency of the silage

GROUP	TOTAL POUNDS DRY MATTER PER 100 POUNDS MILK OF 12 PER CENT SOLIDS AT UNIFORM LIVE WEIGHT				RELATIVE EFFICIENCY OF SILAGE	
	First year	Second year	Average*	From silage*	Equal to 100 pounds early	Acres to equal early
Early	81.33	116.29	101 31	55.37	100.0	1.00
Medium	90.06	116 71	103.39	55.01	102.7	0.77
Late	76.79	105.19	93.02	37.75	134.7	0.82

* Weighted average.

When the two trials are arranged, and an attempt made to rate the acre values of the three types, the data shown in table 9 is obtained.

During both years the dry matter required to produce 100 pounds of milk was least with the immature (late) silage, and greatest with the medium. This difference is undoubtedly due to the difference in the proportion of grain fed, the late group consuming considerably more grain and the medium group the least amount (least with the medium, because the production was least). The pounds of dry matter from silage for each

100 pounds of milk for the early, medium and late was 55.37, 55.01, and 37.75 respectively.

On this basis, 100 pounds of early silage was equivalent to 102.7 pounds medium silage, and 134.7 pounds late silage. Calculating to the acre yield (table 2) 0.77 of an acre of medium and 0.82 of an acre of late were equivalent to an acre of the early corn.

Table 10 is arranged to show the milk production value per acre from the two years' trials.

TABLE 10

Showing milk production value of silage

GROUP	PER 100 POUNDS 12 PER CENT MILK—WEIGHTED			MILK PER POUND DIGESTIBLE DRY MATTER	MILK FROM DIGESTIBLE DRY MATTER IN SILAGE	SILAGE TO FURNISH 1 POUND DIGESTIBLE DRY MATTER WEIGHTED	SILAGE FOR 1 POUND MILK	MILK PER ACRE
	Dry matter	Digestible dry matter	Digestible dry matter from silage					
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
Early	101.31	67.81	36.54	1.47	53.71	5.2	3.5	7078
Medium	103.39	68.65	35.75	1.46	52.20	6.1	4.2	7663
Late	93.02	62.27	24.16	1.61	35.39*	7.9*	5.4	7527

* Average of milk per pound dry matter as determined with Early and Medium is used in this calculation. The greater amount of grain consumed by the Late Group furnished these cows with a ration of greater digestibility which account for the better showing of this Group in column 3 (Table 10). In the first trial the amount of grain required daily by the Early, Medium and Late Groups was 9.97, 8,31 and 11.60 pounds respectively; and in the second trial it is 7.3, 7.2, and 8.6 pounds respectively.

The calculations in this table are on the basis of the dry matter consumed and coefficients of digestibility from appendix table II, Henry and Morrison's Feeds and Feeding, 18th edition. The coefficient applied to the grain mixture, 77 per cent, is a weighted average. For the hay, 55 per cent was used, for the early silage 66 per cent, for the medium silage 65 per cent, and for the late silage 64 per cent.

A pound of digestible dry matter in the silage was assumed to have the same value as one pound of digestible matter in the hay and grain. While this is not strictly true, as is well known and as is shown in column 3 (table 10), it furnishes a satisfactory basis for comparison when the milk per pound of dry matter for the early and medium silage in column 5 is applied, which then only assumes that the digestible dry matter of the different silages is of equal value; and the amounts of silage actually consumed are nearly identical.

Column 6 (table 10) gives the amount (pounds) of silage required to produce one pound of digestible dry matter and column 7 gives the pounds of silage required to produce one pound of 12 per cent milk (including maintenance). On this basis it was found that an acre of early (12.4 tons) will produce 7078 pounds milk, the medium (16.5 tons) 7663 pounds, and the late (20.3 tons) 7527 pounds. This comparison indicates that such an early corn as Pride of the North will not feed enough better to offset its low comparative acre yield; but Leaming, which forms good ears and makes a good yield has a greater production value than either of the others.

It is realized that these calculations cannot be considered final. They are offered as the present attempt at solving the problem. A third year's feeding trial is now being run. Further work needs to be done to compare the dry matter values of the different silages. This is an experiment which it is planned to carry out in 1924. There is also a possibility that there are greater losses in dry matter in the silo from some types than from others which is a point we hope to determine. Then there is the question of cost of growing and ensiling the different types.

SUMMARY

The second year results support those of the first year. All of the silages were a little more mature the second year, containing more dry matter, and this was markedly true of the early silage.

The grain required per 100 pounds of milk when the amounts of hay and silage were the same for all groups was 28.94, 34.28 and 39.60 pounds respectively for early, medium and late silage.

The area of corn required by medium and late to equal an acre of early in feeding value (two years combined) is 0.77 and 0.82 respectively.

The silage required for one pound of milk of 12 per cent solids is 3.5 pounds of early, 4.2 pounds of medium and 5.4 pounds of late.

The pounds of milk produced per acre of silage is 7078 from early (12.4 tons), 7663 from medium (16.5 tons) and 7527 from late (20.3 tons). These yields were obtained from cows during their first five lactation months.

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THE DETERMINATION OF FAT IN BUTTERMILK

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INTRODUCTION

An accurate method for the determination of fat in buttermilk is necessary in order to control the exhaustiveness of the churning process. Some of the larger creameries are so equipped that it is possible to determine churn losses by means of a chemical analysis of the buttermilk. The Roese-Gottlieb and Mojonnier tests are the ones commonly used for this purpose. In most cases, however, the testing equipment in the smaller plants consists only of the Babcock test outfit, which affords a cheap and rapid method for the determination of fat in milk products.

Certain procedures have been developed and certain types of test bottles have been produced for testing whole milk and cream, but for buttermilk there is no standard method of testing, nor is there an adequate test bottle. Buttermilk is tested in the ordinary 18-gram skim milk bottle, which is graduated from 0.0 to 0.25 of 1 per cent (a few bottles graduated from 0.0 to 0.50 of 1 per cent are being put on the market), whereas the amount of fat in buttermilk will, in some cases, exceed 1 per cent. It is only in extremely rare instances that the calibrated portion of the neck of the skim milk bottle is of sufficient size to measure the fat contained in an 18-gram sample of buttermilk.

It was for the purpose of determining the limitations of the Babcock method for testing buttermilk, and if possible of devising a satisfactory modification, that this investigation was carried on.

PLAN OF WORK

The experiment was so conducted as to obtain information on the following points:

A. The conditions limiting the use of the Babcock test for buttermilk.

1. The amount of sulphuric acid used.
2. The length of the whirling period.
3. The speed of centrifuging.

B. A comparison of the Babcock, Normal Butyl Alcohol, (1) and Roese-Gottlieb methods for determining the amount of fat in buttermilk.

METHOD OF PROCEDURE

The buttermilk used in the experimental work was obtained from the churning of neutralized cream in a Dual churn and worker.[1]

All the Babcock and Normal Butyl Alcohol tests were conducted in an electric centrifuge with speed adjustment ranging from 850 to 1700 revolutions per minute, and having a 22-inch disc.

The acid was measured directly into the test bottle from a burette, as it was found that accurate measurements could not be obtained by the use of an acid measure or graduated cylinder. The sulphuric acid used had a specific gravity of 1.83.

Skim milk bottles graduated from 0.0 to 0.50 of 1 per cent were used for the normal butyl alcohol tests, and bottles graduated to 0.25 of 1 per cent were used for the Babcock tests.

ROESE-GOTTLIEB DETERMINATIONS

In general, the procedure as given by the Association of Official Agricultural Chemists (2) was followed in the Roese-Gottlieb determinations. Three extractions with ether were made in each case. It was found necessary to use more ammonia than is needed in testing other milk products, and it was often necessary to add ammonia in the second and third extractions in order to break the emulsion which formed upon the addition of ether. The total amount of ammonia used for a 5-gram sample varied from 2 to 6 cc.

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[1] With the exception of sample 12, table 4, which was hand churned buttermilk.

THE NORMAL BUTYL ALCOHOL TEST

The Normal Butyl Alcohol procedure was that reported by Prof. W. J. Mitchell (1) and was as follows:

Chemicals: Commercial sulphuric acid. Normal butyl alcohol

1. Add the chemicals and buttermilk to the test bottle in the following amounts and in the order indicated:

   (a) 2 cc. of n-butyl alcohol
   (b) 9 cc. of buttermilk
   (c) 7–9 cc. of commercial sulphuric acid.

Vary amount of acid to suit its strength. The right amount is being used when the fat column is golden yellow to light amber in color.

2. Mix contents of bottle thoroughly
3. Centrifuge for 6 minutes
4. Add hot water (soft or distilled) to fill bottle to bottom of neck, and whirl 2 minutes.
5. Add balance of water to float fat into neck and again whirl 2 minutes.
6. Read at a temperature of 135°–140°F. Double the reading to obtain percent of fat.

THE BABCOCK TEST

The unsatisfactory results of several preliminary tests following the more common method of testing buttermilk, which makes use of an 18-gram sample and about 20 cc. of commercial sulphuric acid, led to a study of the following variations of the Babcock test for buttermilk.

1. A 10-gram sample (as measured by a 10-gram Mojonnier pipette) was used.
2. Comparative tests were made, using 11 and 13.5 cc. of sulphuric acid.

3. The following three whirling periods were compared:

   a. 20 minutes—20 minutes—10 minutes
   b. 10 minutes—10 minutes—5 minutes
   c. 5 minutes—3 minutes—3 minutes

4. The effect of the speed of centrifuging was determined by a comparison of the results obtained at the following variations:

   a. 850 R. P. M.
   b. 1150 R. P. M.
   c. 1700 R. P. M.

EXPERIMENTAL DATA

A. Conditions limiting the use of the Babcock test for buttermilk

1. The amount of acid used. As the maximum amount of acid that could be used without danger of charring the fat globules had been found to be 13.5 to 14 cc. (sp. gr. 1.83), 13.5 cc. was selected as the maximum amount of acid to be used in the investigation. Eleven cubic centimeters was arbitrarily selected as the minimum quantity that would be used in determining the importance of the amount of acid. The influence of the amount of acid is shown by table 1.

Table 1 gives a comparison of the results obtained from running seven different samples at a 10–10–5 whirling period and at 1150 R.P.M., using the two different amounts of acid. It will be seen that a much lower reading was obtained from the use of 11 cc. of acid than when 13.5 cc. were used. The average percentage of fat obtained with 13.5 cc. of acid was more than twice that obtained with 11 cc. of acid. These data clearly show the importance of using the maximum amount of acid.

2. The length of the whirling period. The following tables present a comparison of the results obtained from three different whirling periods at a speed of 850 R.P.M. using 13.5 cc. of acid, and from two different whirling periods at a speed of 1150 R.P.M. using both 11 and 13.5 cc. of acid.

These data show that the length of the period of centrifuging is of minor importance. Under the conditions indicated in part I of the table the longer whirling periods resulted in slightly higher average fat percentages. By comparing the averages given in parts I and II it will be seen that when 13.5 cc. of acid were used the longer whirling periods gave higher results only at the lower speed and even then the increase was slight. The only really appreciable increase in the test obtained from a longer whirling period is shown by the figures given in part III. These data indicate that when the minimum amount of acid (11 cc.) was used, the longer whirling period resulted in an increase in the average reading from 0.201 to 0.262 per cent, an increase of about one third. However, by referring to part II of the table, it will be seen that when 13.5 cc. of acid were used at a speed of 1150 R.P.M. as high results were obtained from a 10–10–5 period of centrifuging as from a 20–20–10 period.

TABLE 1

The influence of the amount of acid used

Speed of centrifuge—1150 R.P.M. 10–10–5 whirling period

SAMPLE NUMBER*	11 CC. ACID	AVERAGE	13.5 CC. ACID	AVERAGE
	per cent	*per cent*	*per cent*	*per cent*
1	0.11		0.36	
	0.14	0.125	0.36	0.360
2	0.19		0.33	
	0.19	0.190	0.36	0.345
3	0.21		0.47	
	0.19	0.200	0.49	0.480
4	0.23		0.43	
	0.16	0.195	0.43	0.430
5	0.16		0.47	
	0.16	0.160	0.49	0.480
6	0.13		0.40	
	0.13	0.130	0.40	0.400
7	0.41		0.54	
	0.41	0.410	0.54	0.540
Average......		0.202		0.434

* Sample numbers that recur in other tables refer to the same buttermilk.

TABLE 2

The effect upon the results of varying the whirling period

SAMPLE NUMBER	WHIRLING PERIOD					
	5-3-3	Average	10-10-5	Average	20-20-10	Average
Part I. Speed of centrifuge—850 R.P.M.; amount of acid used—13.5 cc.						
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
4	0.38		0.45		0.44	
	0.38	0.380	0.43	0.440	0.38	0.410
6	0.40		0 40		0.40	
	0.41	0.405	0.41	0.405	0.43	0.415
7	0.47		0.52		0 56	
	0.53	0.500	0.54	0.530	0.56	0.560
8	0.70		0.76		0.72	
	0 69	0.695	0.74	0.750	0 74	0.730
9	0.38		0.38		0.45	
	0.38	0.380	0.36	0.370	0 45	0.450
10	0 37		0.35		0.42	
	0.36	0.365	0.36	0.355	0.42	0.420
Average ...		0.454		0.475		0.497
Part II. Speed of centrifuge—1150 R.P.M.; amount of acid used—13.5 cc.						
1			0.36		0 31	
			0.36	0.360	0.36	0.335
2			0.36		0.33	
			0.33	0.345	0.36	0.345
3			0.47		0.45	
			0.49	0.480	0.49	0.470
4			0.43		0.43	
			0 43	0.430	0.43	0.430
5			0.49		0.49	
			0.47	0.480	0.47	0.480
7			0.52		0.54	
			0.54	0.530	0.54	0.540
Average ...				0.438		0.433

TABLE 2—*Continued*

SAMPLE NUMBER	WHIRLING PERIOD					
	5-3-3	Average	10-10-5	Average	20-20-10	Average
Part III. Speed of centrifuge—1150 R.P.M.; amount of acid used—11 cc.						
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1			0.14		0.16	
			0.11	0.125	0.18	0.170
2			0.19		0.19	
			0.19	0.190	0.22	0.205
3			0.21		0.27	
			0.19	0.200	0.31	0.290
4			0.16		0.24	
			0.23	0.195	0.27	0.255
5			0.16		0.27	
			0.16	0.160	0.31	0.290
6			0.13		0.13	
			0.13	0.130	0.13	0.130
7			0.41		0.49	
			0.41	0.410	0.50	0.495
Average ...				0.201		0.262

3. The speed of centrifuging. To determine whether or not increasing the speed of centrifuging would increase the reading, comparisons were made between the results obtained by running the same samples at 850 R.P.M. and at 1150 R.P.M. with 10-10-5 whirling periods, and between 1150 and 1700 R.P.M. with 20-20-10 whirling periods. In all cases 13.5 cubic centimeters of sulphuric acid (the amount found to give best results) were used. It was found that when the speed of the centrifuge was increased to 1700 R.P.M. several of the test bottles were broken by the increased pressure exerted upon them. For this reason and because it was thought that any increase in reading to be obtained from the higher speed would be more noticeable with a 20-20-10 whirling period than with the shorter ones, it

TABLE 3

Table showing the effect upon the test of varying the speed of centrifuging

Part I. 10–10–5 Whirling period—13.5 cc. acid used

SAMPLE NUMBER	850 R.P.M.	AVERAGE	1150 R.P.M.	AVERAGE
	per cent	*per cent*	*per cent*	*per cent*
4	0.45		0.43	
	0.43	0.440	0.43	0.430
6	0.40		0.40	
	0.45	0.425	0.40	0.400
7	0.52		0.54	
	0.54	0.530	0.54	0.540
8	0.74		0.67	
	0.76	0.750	0.71	0.690
9	0.36		0.39	
	0.38	0.370	0.39	0.390
10	0.35		0.35	
	0.36	0.355	0.35	0.350
Average		0.478		0.467

Part II. 20–20–10 Whirling period—13.5 cc. acid used

	1150 R.P.M.	AVERAGE	1700 R.P.M.	AVERAGE
	per cent	*per cent*	*per cent*	*per cent*
1	0.36		0.35	
	0.36	0.360	0.36	0.355
2	0.33		0.31	
	0.36	0.345	0.34	0.325
3	0.45		0.45	
	0.49	0.470	0.45	0.450
4	0.43		0.43	
	0.43	0.430	0.44	0.435
5	0.47		0.49	
	0.49	0.480	0.49	0.490
7	0.54		0.53	
	0.54	0.540	0.58	0.555
Average......		0.438		0.435

was deemed advisable to use the high speed only with the longer whirling periods.

The data in table 3 show that when using 13.5 cc. of acid and 10–10–5 whirlings as high results were obtained with a speed of 850 R.P.M. as with 1150 R.P.M. Increasing the speed to 1700 R.P.M. gave no higher results than those obtained at 1150 R.P.M., even with the 20–20–10 whirling periods.

B. A comparison of the Babcock, Normal Butyl Alcohol, and Roese-Gottlieb methods for determining the per cent of fat in buttermilk

As a result of the foregoing data, the following modification of the Babcock method was decided upon for a comparison with the Normal Butyl Alcohol and Roese-Gottlieb methods of determining the fat in buttermilk.

10-gram sample
13.5 cc. of acid (measured from a burette)
10–10–5 whirling period
1150 R.P.M.

A comparison of the results obtained by the Babcock and Roese-Gottlieb methods shows that the Babcock results are always less than those of the Roese-Gottlieb. It was noticed, however, that the difference between the two was fairly constant, being in the neighborhood of 0.2 of 1 per cent. (The average difference between the results obtained on the 12 samples is 0.2047.) In other words, practically 0.2 of 1 per cent of the fat in buttermilk is held so tightly by the milk constituents that the combined action of the acid and centrifugal force fails to liberate it. The same fact is true in testing whole milk, in which test a correction is made for the approximate 0.2 of 1 per cent fat that does not rise in the neck, by reading the fat column to the top of the meniscus.

By using 0.2 as a correction factor and adding it to the results obtained by the Babcock method, a value is obtained which is closely comparable to that obtained by the Roese-Gottlieb method.

TABLE 4

A comparison of the modified Babcock, Normal Butyl Alcohol, and Roese-Gottlieb methods for determining the fat in buttermilk

SAMPLE NUMBER	BABCOCK[1]	AVERAGE	BABCOCK PLUS 0.2	NORMAL BUTYL ALCOHOL	AVERAGE	ROESE-GOTTLIEB	AVERAGE
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1	0.36			0.58		0.590	
	0.36	0.360	0.56	0.58	0.580	0.572	0.5810
2	0.36			0.53		0.545	
	0.33	0.345	0.545	0.53	0.530	0.544	0.5445
3	0.49			0.69		0.667	
	0.47	0.480	0.68	0.68	0.685	0.664	0.6655
4	0.43			0.60		0.628	
	0.43	0.430	0.63	0.60	0.600	0.626	0.6270
5	0.49			0.68		0.698	
	0.47	0.480	0.68	0.68	0.680	0.685	0.6915
6	0.40			0.54		0.596	
	0.40	0.400	0.60	0.54	0.540	0.598	0.5970
7	0.54			0.72		0.759	
	0.54	0.540	0.74	0.72	0.720	0.772	0.7655
8	0.71			0.94		0.904	
	0.67	0.690	0.89	0.94	0.940	0.897	0.9005
9	0.39			0.56		0.570	
	0.39	0.390	0.59	0.55	0.555	0.570	0.5700
10	0.35			0.56		0.566	
	0.35	0.350	0.55	0.56	0.560	0.554	0.5600
11	0.44			0.62		0.662	
	0.44	0.440	0.64	0.62	0.620	0.645	0.6535
12	1.29			1.50		1.485	
	1.29	1.29	1.49	1.50	1.50	1.500	1.4925
Average		0.516	0.716		0.709		0.7207

[1] Procedure followed:

R.P.M.-1150
10-gram sample
18-gram 0.25 per cent skim milk bottle
13.5 cc. H_2SO_4 in burette
10–10–5 whirling periods

In addition, the data in table 4 confirm the work of Professor Mitchell (1) in that the results obtained by the Normal Butyl Alcohol method correspond closely with those obtained by chemical analysis.

DISCUSSION OF THE TESTS

The results of the work indicate that the amount of acid added is the most important factor to be considered in using the Babcock test for buttermilk. Another very important factor, which does not appear in the data presented, is the construction of the skim milk bottle used. Many bottles are so constructed that they "choke up" very easily at the base of the graduated capillary. A slight constriction at this opening will result in preventing some of the fat from rising into the neck of the bottle. By carefully selecting the test bottles and eliminating those that repeatedly "choke up" this difficulty was lessened. For this reason, in selecting bottles that are to be used in the test, choose those that have the graduations close together as this indicates a wide capillary. Too much emphasis cannot be laid upon the need of a test bottle that is properly constructed for the testing of buttermilk.

The Normal Butyl Alcohol test also is somewhat handicapped by the lack of a desirable test bottle. Otherwise the method is very successful.

DIRECTIONS FOR OPERATING THE MODIFIED BABCOCK TEST FOR BUTTERMILK

As a result of this experiment, the following modification of the Babcock test for determining the fat in buttermilk is presented:

1. If the sample contains visible granules of butterfat, it should be strained through cheesecloth, as floating granules of butter are not indicative of the exhaustiveness of churning.
2. Thoroughly mix the sample.
3. By means of a 10-gram Mojonnier pipette, measure 10 grams of the buttermilk to be tested into a skim milk bottle (use a 0.5 per cent bottle if possible).

4. Add 13.5 cc. of commercial sulphuric acid (having a specific gravity of 1.82–1.83) from a burette or 14 cc. from an acid measure, and mix well.

5. Centrifuge at a speed of about 1000 R.P.M. for ten minutes.

6. Fill to base of the neck of bottle with hot water and whirl for ten minutes.

7. Finish filling bottle with hot water and whirl for five minutes.

8. Allow to remain five minutes in a hot water bath having a temperature of 135–140°F.

9. Read to the top of the meniscus and multiply the result by 1.8. (The fat column should be a dark amber color. If it is a straw yellow color, the amount of acid used should be increased.)

10. Add the correction factor of 0.2.

PRECAUTIONS

1. Be sure the sample is well mixed before pipetting.

2. Be sure the acid is of proper strength. If a deep amber colored fat column does not result, increase the amount of acid used.

3. Add only enough water the first time to raise the mixture in the bottle up to the point where the graduated neck is joined to the shoulder of the bottle. If a little clearance is left between the top of the liquid in the bottle and the opening into the graduated portion of the neck, the danger of "choking" the neck of the bottle will be diminished, as the final addition of water will cause only the collected fat to rise into the graduated portion of the neck.

4. Mark the bottles that "choke up" and eliminate those that repeat.

CONCLUSIONS

1. The amount of acid used has a very important effect upon the results obtained in the Babcock method of testing buttermilk.

2. The extension of the whirling period beyond the 10–10–5 minute periods has no appreciable effect upon the result obtained in the Babcock method of testing buttermilk.

3. Increasing the speed of the centrifuge above 900–1000 revolutions per minute will not increase the readings obtained in the Babcock method of testing buttermilk.

4. With the proper modifications of the Babcock test and with the addition of a correction factor of 0.2, results can be obtained that will conform closely to the Roese-Gottlieb determination.

5. The results of the Normal Butyl Alcohol method of testing buttermilk check closely with the Roese-Gottlieb determination.

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COMPARISON OF METHODS OF READING CREAM TESTS

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There has been and still is quite a wide difference of opinion in regard to the manner of reading the Babcock cream test. Even in the last publication of the Official Methods of Analysis of the Association of Official Agricultural Chemists, no specific directions are given concerning the manner of reading the finished test. This text refers the analyst to either Farrington and Woll or to Van Slyke. This is a particularly unfortunate statement since the two references cited do not agree as to the manner of reading cream tests. We find that in Farrington and Woll the cream tester is directed to read the finished test by measuring the fat column the same as for a milk test—that is, from the extreme low point of the lower meniscus to the extreme upper point of the top meniscus, while Van Slyke states that the top meniscus of the finished test should be flattened by the use of glymol, separator oil, amyl alcohol, or fat saturated alcohol. Neither of these authors show any comparison of their method with any of the extraction methods as proof of their own.

In consulting other authors and bulletins we find that several other methods are advised, very few of which are actually supported by comparison either with the Roese Gottleib (a recognized official and accurate method) or any continuous extraction method.

Hunziker in his texts advises the use of glymol to flatten the upper meniscus or in its absence to include one-third of the upper meniscus in the reading.

Wing in his Manual of Milk Products advises Farrington and Woll's method of reading to the extremes of the fat column.

McKay and Larsen suggest the use of light mineral oil, Troy and McInerney, red reader (glymol), Fisk, glymol, and Babcock and Farrington fat-saturated-alcohol, to flatten the upper meniscus and insure an accurate reading.

Webster introduces further complications by stating that the cream test should be read from the bottom of the fat column to the extreme top and then to deduct four-fifths of the depth of the top meniscus from this reading for an 18 gram charge. In the case of a 9 gram charge used in an 18 gram bottle he states that 0.2 should be added after the reading is doubled.

Shaw in the Government Bulletin entitled, "Chemical Testing of Milk and Cream" directs the tester to read the cream test from the bottom of the lower meniscus to the bottom of the upper.

Erf and Cunningham agree with Indiana Bulletin 145 that the use of glymol gives the most accurate results and in the absence of glymol the test should be read from the lowest point of the fat column to the bottom of the clear part of the upper meniscus.

Gregory and Hammond in the recent Purdue Circular No. 78 Revised, use Hunziker's method of including one-third the top meniscus or flattening the meniscus with glymol.

In all of these tests the lack of substantial data in support of the various methods of reading is striking. It would seem with so many opinions in the field that authorities using a method which does not agree with another would show data to prove their points, but seemingly little work has been done in actually comparing these different methods with the extraction methods which are known to be accurate. In some cases these comparisons were probably made but the results are very hard to find.

Siegmund and Craig of Baltimore claim that the tests for cream using the glymol method were about 1.5 per cent too high and that by increasing the speed of the centrifuge to twice the correct figure they were able to obtain practically indentical results between the Babcock and extraction methods.

Ross and McInerney in Cornell Bulletin No. 337 advise the use of glymol and give figures comparing the readings using glymol with readings without glymol. They find that the glymol readings fall under the other readings about 1.5 per cent on 6 inch bottles and 1 per cent on 9 inch bottles. They do not state what method of reading they used on the tests where no glymol was used but it is presumed that they included one-third of the upper meniscus according to Hunziker whom they refer to.

They also, in the same bulletin, give the results of the analysis of 64 cream samples by both the Babcock glymol and a method they term chemical, presumably an extraction method. The results of these analyses check very closely, in fact only 8 varied more than 0.5 per cent which is the finest division on the usual cream bottles.

There are probably other methods of reading cream tests and quite possibly other data in support of the tests but they have not come to the writer's attention.

There seems to be no reason why some definite and specific method, supported by substantial data from various sources, cannot be written into the "Official Methods" and put an end once and for all to the confusing differences of opinion now existing. It would seem that on the face of it the methods using a "meniscus remover" or "red reader" would give more consistant results than any method which adds or subtracts a fraction of the upper meniscus, since the depth of meniscus varies with the diameter of the neck and the meniscus outline is far from distinct.

Believing that this subject should bear investigation and further, that a small number of comparisons made at several different places by different investigators are more desirable than a large number run at one place we therefore submit the following with the suggestion that it be further tried elsewhere.

The following table shows the results of our work.

SAMPLE	TO BOTTOM OF UPPER MENISCUS	TO EXTREME TOP OF UPPER MENISCUS	USING GLYMOL BOTTLE A	USING ALCOHOL FAT-SATURATED BOTTLE B	ONE-THIRD OF MENISCUS	ROESE GOTTLIEB-OFFICIAL
1 A...........	18.50	20.00	18.75		19.00	18.80
B...........	18.50	20.00		19.00		18.71
2 A...........	20.00	21.50	20.00		20.50	19 90
B...........	20.00	21.50		20.50		19.96
3 A...........	29.50	31.00	29.50		30.00	29.21
B...........	29.50	31.00		30.00		29.22
4 A...........	38.00	38.75	38.00		38.45	37.62
B...........	38.50	39.25		38.50		37.68
5 A...........	33.50	34.25	32.75		33.45	32.14
B...........	33.25	34.00		33.00		32.16
6 A...........	16.50	18 00	16.50		17.00	16.30
B...........	16.50	18.00		17.00		16.34
7 A...........	22.00	23.50	22 00		22.50	21.74
B...........	22.00	23.50		22.25		21.82
8 A...........	26.50	27.50	26.50		26.83	26.13
B...........	26.50	27.50		27.00		26.14
9 A...........	35.50	36.25	35.25		35.75	34.87
B...........	35.50	36.25		36.00		34.95
10 A...........	25.25	26.50	25.50		25.50	25.08
B...........	25.25	26.50		25.75		25.12
Average	26.51	27.72	26.47	26.90	26.90	26.19
Variation....	+0.32	+1.53	+0.28	+0.71	+0.71	0

PROCEDURE

The ten samples of cream were obtained by separating evenings milk obtaining a portion of cream testing about 38 per cent. This portion was then used in preparing samples of 10 different tests by diluting with various amounts of whole milk. These samples were held at 40°F. until the following morning when the analyses were made after warming the cream to 100°F. and thoroughly mixing by pouring into individual dry beakers.

The cream was weighed on a Troemner, agate knife edge balance to the nearest 0.005 gram. Nine gram 50 per cent, 6 inch cream bottles were used in all cases with a 9 gram charge and an addition of 9 cc. of distilled water. The amount of acid (1.822 specific gravity) was determined by trial and no results were included that did not show an absolutely clear and perfect fat column. Amounts used varied from 17.0 to 18.0 cc. depending on test of cream. The centrifuge was an electric machine heated electrically to 145°F., diameter of wheel 15 inches and run at a speed of 900 R.P.M. Centrifuge periods of 5, 2 and 1 minutes were used with two additions of distilled water at 180°F. The bottles were tempered for 4 to 5 minutes at 138°–42°F. and read at these temperatures, direct from the bath. Readings for the first and second columns of the table were made at the same time after which the bottles were returned to the bath and retempered for a minute or two. Glymol colored with alkanet was then added to the A bottles and the test reread while fat-saturated-alcohol colored with alizarine was added to the B bottles in a similar manner. These additions were made carefully down the side of the tube to a depth of about $\frac{3}{8}$ inch.

The readings in column 5, including one-third the meniscus were obtained as follows: the test for each sample in columns 1 and 2 were averaged and the variations due to the depth of meniscus obtained by difference after which one-third of this difference was added to the average test obtained in column 1.

The results in column 6 were obtained following the Roese-Gottlieb method exactly as outlined in the Official Methods, with the exception that Mojonnier extraction flasks were used in place of a Röhrig tube. Both ethers were redistilled at low temperatures before use and the flasks extracted with 2–25 cc. charges of each ether followed by a final 15 cc. charge of each. The flasks containing the fat were dried to constant weight.

INTERPRETATION

Our results show that the method using glymol checks closest with the Roese-Gottlieb; the variation being plus 0.28 per cent while the method of Shaw, reading from the bottom of the lower to the extreme low point of the upper, gives practically identical results, the variation being plus 0.32 per cent.

The other methods used however are more than 0.5 per cent out of the way. This was a surprise in the case of the fat-saturated-alcohol, which varied plus 0.71 per cent. It was thought that this method would check rather closely with the glymol. It was noticed in all the bottles, however, that the alcohol did not give as flat a top line as the glymol, the tendency being to change the concave of the meniscus to a convex line between the fat and the alcohol. We read to the top of this convex surface which may explain this result.

The method recommended by Hunziker and quoted by others of including one-third of the meniscus, gave results which were high by plus 0.71 per cent being the same as those obtained with the alcohol.

Basing our opinion on these results it would seem that either Shaw's method or the glymol method of reading cream tests is the most accurate. However, since there are various types of bottles in use and various methods of treating the charge as regards the amount of acid, more work should be done to justify the above statement.

THE RELATION OF THE OXIDIZABILITY VALUE AND THE AMINO AND AMMONIA NITROGEN CONTENT TO THE QUALITY OF CREAM AND BUTTER

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Previous work on the relation of amino nitrogen and ammonia to total nitrogen[1, 2] and on the volatile oxidizable substances[3] in cream and butter showed that these determinations might give some indication of the kind of cream used in making a given sample of butter. Inasmuch as this work had been confined to one creamery in the Middle West and one in the East, it seemed advisable to make investigations on samples which represented a greater portion of the butter that enters into commerce. Accordingly, representative samples of cream and butter from eleven different creameries throughout the Central States and two in the East were collected and forwarded to Washington for chemical examination.[4]

Portions of each sample of cream were treated with acetic acid and picric acid, filtered and the filtrates, together with some of the cream preserved with formaldehyde, were sent to Washington for determination of total nitrogen, and amino nitrogen and

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[1] A method for the determination of amino nitrogen and ammonia in cream and butter. Journal of Dairy Science, v, no. 4, July, 1922.

[2] Some determinations on the soluble nitrogen compounds in cream and butter. Journal of Dairy Science vi, no. 3. May, 1923.

[3] The volatile acids and the volatile oxidizable substances of cream and experimental butter. Journal of Dairy Science, iv, no. 6, p. 521, 1921.

[4] All field work, including collection and preparation of samples, and all microscopic counts, were made by Mr. W. R. North, Jr., Mr. G. F. Reddish, and Dr. Edwin LeFevre of this Bureau, and acknowledgment is hereby made.

Appreciation is also expressed to Mr. J. I. Palmore, Miss D. B. Scott and Mr. L. Jones, for assistance in chemical determinations.

ammonia. By this procedure the amino nitrogen and ammonia found represented the amount actually present at the time the cream was sampled. Duplicate portions of the cream were also sent by mail, without refrigeration, to the nearby Chicago Station for determination of oxidizability value. Since these samples contained no preservative, the time between collection of sample and analysis should be taken into consideration. This time, in the majority of cases, was from one to three days, although one sample was seven days, two samples six days, one sample five days,

TABLE 1

Plant 1

SAMPLE NUMBER	GRADE OF CREAM	SCORE OF BUTTER	OXIDIZABILITY VALUE BUTTER	AMINO NITROGEN AND AMMONIA AS PER CENT OF TOTAL NITROGEN	
				Cream	Butter
1	Sweet	94	1.3	1.5	1.2
2	Sweet	94	1.3	1.7	1.3
3	Sweet	94	1.2	1.7	0.7
4	Sweet	94	0.7	1.9	0.7
5	Sweet	93½	1.9	2.0	1.8
6	Sweet	93½	0.9	1.1	1.0
7	Sweet	94	0.7	1.3	1.4
Average......		$93\frac{6}{7}$	1.1	1.6	1.2

Cream contained practically no yeasts or oidia.

TABLE 2

Plant 2

SAMPLE NUMBER	GRADE OF CREAM	SCORE OF BUTTER	OXIDIZABILITY VALUE BUTTER	AMINO NITROGEN AND AMMONIA AS PER CENT OF TOTAL NITROGEN	
				Cream	Butter
1	Sweet	93	0.1	1.9	0.9
2	Sweet	93½	0.3	1.6	0.7
3	Sweet	94	0.3	1.9	0.4
4	Sweet	93	0.5	2.1	1.1
5	Sweet	93	0.6	1.5	0.9
Average......		$93\frac{8}{10}$	0.4	1.8	0.8

Cream contained practically no yeasts or oidia.

and five samples four days in transit. However, since some samples only one day in transit gave higher oxidizability values than others four days, this delay does not seem very significant.

TABLE 3

Plant 3

SAMPLE NUMBER	GRADE OF CREAM	SCORE OF BUTTER	OXIDIZABILITY VALUE		AMINO NITROGEN AND AMMONIA AS PER CENT OF TOTAL NITROGEN	
			Cream	Butter	Cream	Butter
1	1	89 s		1.3	5.5	3.0
2	1	89 s		2.4	5 8	2.5
Average		89		1.8	5.6	2.7

s = Salted.

Yeast count on cream varied from 1,600,000 to 4,400,000.

Oidia count on cream varied from 230,000 to 420,000.

TABLE 4

Plant 4

SAMPLE NUMBER	GRADE OF CREAM	CREAM SAMPLE FOR OXIDIZABILITY VALUE IN TRANSIT	SCORE OF BUTTER	OXIDIZABILITY VALUE		AMINO NITROGEN AND AMMONIA AS PER CENT OF TOTAL NITROGEN	
				Cream	Butter	Cream	Butter
		days					
1	1	3	89½ (89) s	50 4	1.8	5.5	3.4
2	1	3	90 (89) s	46.1	1.2	6.4	4.1
3	1	1	91 (88) s	39.7	4.1	6.6	3.3
4	1	2	89 (87½) s	47 7	3.2	6 9	3.0
5	2	3	(85) u	53.7	7.7	7.7	3.5
6	2	3	(84) u	66.9	4.1	7.7	4 4
7	2	1	(85) u	52.8	11.9	8.0	5.5
8	2	2	(84) u	69.7	11.2	9.1	5.3
First grade average........			88 4	46.0	2 6	6 3	3.4
Second grade average......			84 5	60.8	8 7	8.1	4.7

s = Salted.

u = Unsalted.

Yeast count on cream varied from 4, 375,000 to 9,500,000.

Oidia count on cream varied from 625,000 to 1,825,000.

Butter scores in parenthesis were given by Mr. G. R. Campbell of Dairy Division at the time the butter samples were analyzed.

The other scores in this table were on duplicate portions kept in cold storage 25 days.

The corresponding samples of butter were forwarded to Washington in refrigerator cars, the samples reaching their destination in from 13 to 43 days, with the exception of those from plant no. 9, which were delayed 88 days. As soon as the butters were received they were scored by Mr. S. C. Thompson of the Dairy Division of the United States Department of Agricul-

TABLE 5

Plant 5

SAMPLE NUMBER	GRADE OF CREAM	CREAM SAMPLE FOR OXIDIZABILITY VALUE IN TRANSIT	SCORE OF BUTTER	OXIDIZABILITY VALUE		AMINO NITROGEN AND AMMONIA AS PER CENT OF TOTAL NITROGEN	
				Cream	Butter	Cream	Butter
		days					
1	1	2	89½ u	43.2	3.8	6.4	4.9
2	1	1	89½ u	48.0	5.6	6.8	4.8
3	1	1	90 u	43.8	4.3	7.7	4.6
4	2	1	88 u	69.8	5.3	8.7	5.2
5	2	2	88 u	52.1	5.7	9.0	5.7
First grade average....			89.7	45.0	4.6	7.0	4.8
Second grade average			88	61.0	5.5	8.8	5.4

u = Unsalted.

Yeast count on cream varied from 3,300,000 to 5,475,000.

Oidia count on cream varied from 950,000 to 2,925,000.

TABLE 6

Plant 6

SAMPLE NUMBER	GRADE OF CREAM	SCORE OF BUTTER	OXIDIZABILITY VALUE		AMINO NITROGEN AND AMMONIA AS PER CENT OF TOTAL NITROGEN	
			Cream	Butter	Cream	Butter
1	1	92s		4.7	7.0	4.6
2	1	92s		3.9	7.1	5.2
3	2	89u		9.0	8.4	5.8
4	2	90u		5.9	9.1	4.6
First grade average . .		92		4.3	7.0	4.9
Second grade average		89½		7.4	8.7	5.2

s = Salted.

u = Unsalted.

Yeast count on cream varied from 340,000 to 1,510,000.

Oidia count on cream varied from 158,000 to 830,000.

TABLE 7

Plant 7

SAMPLE NUMBER	GRADE OF CREAM	CREAM SAMPLE FOR OXIDIZABILITY VALUE IN TRANSIT	SCORE OF BUTTER	OXIDIZABILITY VALUE		AMINO NITROGEN AND AMMONIA AS PER CENT OF TOTAL NITROGEN	
				Cream	Butter	Cream	Butter
		days					
1	1	3	91s	52.5	5.3	6.7	6.1
2	1	3	91s	58.6	4.7	7.2	6.2
3	1	2	89s	49.3	4.7	7.4	5.6
4	1	4	90u	61.4	5.9	7.6	6.8
5	1		90s		6.5	7.8	5.1
6	1	3	90s	54.7	5.3	7.8	5.3
7	1	3	89s	32.6	5.8	8.0	4.3
8	2	3	88u	65.9	6.5	8.5	7.5
9	2	2	88u	54.4	10 3	8.8	5.8
10	2	3	89u	54.1	8.8	8.8	5.8
11	2	4	88s	79.7	6.5	8.9	4.2
First grade average			90	51.5	5.4	7.5	5.6
Second grade average			88½	63.5	8 0	8.7	5.8

s = Salted.
u = Unsalted.
Yeast count on cream varied from 4,700,000 to 7,500,000.
Oidia count on cream varied from 1,300,000 to 2,350,000.

TABLE 8

Plant 8

SAMPLE NUMBER	GRADE OF CREAM	SCORE OF BUTTER	OXIDIZABILITY VALUE		AMINO NITROGEN AND AMMONIA AS PER CENT OF TOTAL NITROGEN	
			Cream	Butter	Cream	Butter
1	1	91s		2.9	6 8	5.0
2	1	89s		3.5	7.8	4.2
3	1	91s		3.5	8.0	4.9
4	2	89s		8.8	8.6	5.1
5	1	89s		1.8	8.7	4.8
First grade average. .		90		2.9	7.8	4.7
Second grade average		89		8.8	8.6	5.1

s = Salted.
Yeast count on cream varied from 140,000 to 1,650,000.
Oidia count on cream varied from less than 5,000 to 170,000.

TABLE 9

Plant 9

SAMPLE NUMBER	GRADE OF CREAM	CREAM SAMPLE FOR OXIDIZABILITY VALUE IN TRANSIT	SCORE OF BUTTER	OXIDIZABILITY VALUE		AMINO NITROGEN AND AMMONIA AT PER CENT OF TOTAL NITROGEN	
				Cream	Butter	Cream	Butter
		days					
1	1		90s		5 3	6.5	3.2
2	1		90s		3.7	7.1	3.8
3	1	3	89s	46.7	6.2	7.9	5.7
4	2		85*u		9.4	8.4	15.6*
5	2	5	83*u	46.0	9.1	9.3	13.8*
6	2	3	88*u	67.8	8.2	10.5	9.3*
First grade average..........			89⅔	46.7	5.1	7.2	4 2
Second grade average			85⅓*	56.9	8.9*	9 4	12.9

s = Salted.

u = Unsalted.

* The samples of butter from the above creamery were delayed in transit 88 days, which is probably the cause of the unusual results on the unsalted butters.

Yeast count on cream varied from 1,750,000 to 4,900,000.

Oidia count on cream varied from 900,000 to 3,550,000.

TABLE 10

Plant 10

SAMPLE NUMBER	GRADE OF CREAM	SCORE OF BUTTER	OXIDIZABILITY VALUE		AMINO NITROGEN AND AMMONIA AS PER CENT OF TOTAL NITROGEN	
			Cream	Butter	Cream	Butter
1	1				7.3	
2	1	87s		4.3	7.7	4.7
3	1	s		0.3	8.3	4.7
4	2				8.6	
5	2	s		3.4	8.8	6.1
6	1	86s		4.4	9.4	6.1
7	2				10.5	
First grade average....				3.0	8.2	5.2
Second grade average..				3.4	9.3	6.1

s = Salted.

Yeast count on cream varied from 760,000 to 2,730,000.

Oidia count on cream varied from 60,000 to 410,000.

ture and analyzed by the same procedure used in previous work.[1,2,3] Water, fat and total nitrogen were determined on all the butter samples and inasmuch as these results were normal they

TABLE 11

Plant 11

SAMPLE NUMBER	GRADE OF CREAM	CREAM SAMPLE FOR OXIDIZABILITY VALUE IN TRANSIT	SCORE OF BUTTER	OXIDIZABILITY VALUE		AMINO NITROGEN AND AMMONIA AS PER CENT OF TOTAL NITROGEN	
				Cream	Butter	Cream	Butter
		days					
1	1	2	90s	73.6	4.1	7.0	5.0
2	1	2	89s	69.8	5.6	7.4	5.4
3	1	7	89s	74 5	4 1	7.5	5.4
4	1	3	89s	87.2	4.3	8.7	4.9
5	2	6	88s	88.6	4.1	11.7	6.0
6	2	3	88s	85.1	5.3	12.2	4.7
First grade average..........			89¼	76.3	4.5	7 6	5 2
Second grade average........			88	86.8	4 7	11 9	5 3

s = Salted.
Yeast count on cream varied from 3,250,000 to 13,550,000.
Oidia count on cream varied from 1,900,000 to 4,500,000.

TABLE 12

Plant 12

SAMPLE NUMBER	GRADE OF CREAM	CREAM SAMPLE FOR OXIDIZABILITY VALUE IN TRANSIT	SCORE OF BUTTER	OXIDIZABILITY VALUE		AMINO NITROGEN AND AMMONIA AS PER CENT OF TOTAL NITROGEN	
				Cream	Butter	Cream	Butter
		days					
1	1	3	88s	49.3	6.8	7.5	4.2
2	1	2	90s	36 8	7.1	8.6	3.7
3	1	3	89s	47.3	6.2	8.9	4.4
4	1	2	90s	41.9	6.8	9.2	4.1
5	2	4	87u	45.7	8.7	11.9	6.7
6	2		88u		8.5	12.2	6.8
First grade average..........			89¼	43.8	6.7	8.5	4.1
Second grade average........			87½	45.7	8.6	12.0	6.7

s = Salted.
u = Unsalted.
Yeast count on cream varied from 4,000,000 to 7,975,000.
Oidia count on cream varied from 1,175,000 to 3,175,000.

have not been recorded here. The total nitrogen varied from 0.039 to 0.121 per cent. The results obtained for oxidizability value and amino nitrogen and ammonia as per cent of total nitrogen on cream and butter and the score of the butter have been tabulated, the samples from each creamery being arranged according to ascending value for amino nitrogen and ammonia as per cent of total nitrogen on the cream. Both salted and unsalted butters were examined as indicated in the tables. For easy comparison, the averages for each plant have been assembled as shown in table 14. The distinction as to grades of cream refers in each case to the grading of the plant itself. Butter is described as first or second grade to show that it was made from a first or a second grade cream in each case and without consideration of score given to the butter.

TABLE 13

Plant 13

SAMPLE NUMBER	GRADE OF CREAM	CREAM SAMPLE FOR OXIDIZABILITY VALUE IN TRANSIT	SCORE OF BUTTER	OXIDIZABILITY VALUE		AMINO NITROGEN AND AMMONIA AS PER CENT OF TOTAL NITROGEN	
				cream	butter	cream	butter
		days					
1	1	2	90u	62.7	3.7	9.0	5.4
2	1	4	90½u	67.8	3.8	9.2	5.8
3	1	2	89u	68.5	4.8	9.8	7.2
4	1	1	90u	46.1	4.1	10.0	5.8
5	1		90u		3.8	10.0	7.1
6	2	4	87s	54.1	4.8	11.5	5.6
7	2		87s		4.3	13.1	4.3
8	2	3	87s	44.2	3.5	13.3	6.0
First grade average			$89\frac{9}{10}$	61.3	4.0	9.6	6.3
Second grade average			87	49.1	4.2	12.6	5.3

s = Salted.

u = Unsalted.

Yeast count on cream varied from 5,500,000 to 9,900,000.

Oidia count on cream varied from 1,650,000 to 5,250,000.

Plants no. 1 and no. 2 were receiving sweet cream of high quality, practically no yeasts or oidia[5] being found in all the samples. All the butter samples from no. 1 were from cream churned without the addition of starter, with the exception of sample no. 5. Of the butter samples from plant no. 2, all were from cream containing starter except no. 2. The butter from both of these plants scored 93 to 94. The average oxidizability value on the butter was 1.1 and 0.4. The average amino nitro-

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[5] The determination of yeasts and oidia in cream and butter, H. W. Redfield. Journal of Dairy Science, v, no. 1, January, 1922.

TABLE 14

Average results on all plants

PLANT NUMBER	SCORE OF BUTTER	OXIDIZABILITY VALUE		AMINO NITROGEN AND AMMONIA AS PER CENT OF TOTAL NITROGEN	
		Cream	Butter	Cream	Butter
First grade					
1	$93\frac{6}{7}$		1.1	1.6	1.2
2	$93\frac{8}{10}$		0.4	1.8	0.8
3	89		1.8	5.6	2.7
4	$88\frac{4}{10}$	46.0	2.6	6.3	3.4
5	$89\frac{7}{10}$	45.0	4.6	7.0	4.8
6	92		4.3	7.0	4.9
7	90	51.5	5.4	7.5	5.6
8	90		2.9	7.8	4.7
9	$89\frac{2}{3}$	46.7	5.1	7.2	4.2
10			3 0	8 2	5.2
11	$89\frac{1}{4}$	76.3	4.5	7.6	5.2
12	$89\frac{1}{4}$	43 8	6.7	8.5	4.1
13	$89\frac{9}{10}$	61.3	4.0	9.6	6 3
Second grade					
1					
2					
3					
4	$84\frac{1}{3}$	60.8	8.7	8.1	4.7
5	88	61.0	5.5	8.8	5.4
6	$89\frac{1}{2}$		7.4	8.7	5.2
7	$88\frac{1}{4}$	63.5	8.0	8.7	5.8
8	89		8.8	8.6	5.1
9	$85\frac{1}{3}$	56.9	8.9*	9.4	12.9*
10			3.4	9.3	6.1
11	88	86.8	4.7	11.9	5.3
12	$87\frac{1}{2}$	45.7	8.6	12.0	6.7
13	87	49.1	4.2	12.6	5.3

* See footnote plant no. 9, table 9.

gen and ammonia as per cent of the total nitrogen was 1.6 and 1.8 on the cream and 1.2 and 0.8 on the butter from plants no. 1 and no. 2, respectively.

Plant no. 3 was a small creamery receiving cream from short hauls; however, the cream was sour and was pasteurized and churned without having the acidity reduced. The cream contained from 1,600,000 to 4,400,000 yeasts and from 230,000 to 420,000 oidia. The average oxidizability value on the butter was 1.8. The average amino nitrogen and ammonia as per cent of the total nitrogen was 5.6 on the cream and 2.7 on the butter, and the score of the butter was 89.

TABLE 15

Amino nitrogen and ammonia as per cent of total nitrogen, showing range for first and second grades of cream

PLANT NUMBER	FIRST GRADE		SECOND GRADE	
	Minimum	Maximum	Minimum	Maximum
1	1.1	2.0		
2	1.5	2.1		
3	5.5	5.8		
4	5.5	6.9	7.7	9.1
5	6.4	7.7	8.7	9.0
6	7.0	7.1	8.4	9.1
7	6.7	8.0	8.5	8.9
8	6.8	8.0 (8.7)	8.6	
9	6.5	7.9	8.4	10.5
10	7.3	8.3 (9.4)	8.6	10.5
11	7.0	8.7	11.7	12.2
12	7.5	9.2	11.9	12.2
13	9.0	10.0	11.5	13.3

Plant no. 8 received sour cream from short distances, the samples collected containing from 140,000 to 1,650,000 yeasts and from less than 5,000 to 170,000 oidia. The acidity of the cream was reduced to about 0.4 per cent before churning, which is higher than the general practice among centralizers. Only one of the samples of cream from this plant was classed as second grade. The average oxidizability value on the first grade butters was 2.9, and 8.8 on the second grade sample. The average amino nitrogen and ammonia as per cent of the total nitrogen on the first grade samples was 7.8 for the cream and 4.7 for the butter, and for the second grade sample, 8.6 and 5.1, respectively. The second grade butter scored 89 and the first grade samples scored from 89 to 91.

TABLE 16

Showing results of chemical and bacteriological examinations of cream from plants no. 3 and no. 8.

SAMPLE NUMBER	AMINO NITROGEN AND AMMONIA AS PER CENT OF TOTAL NITROGEN	AGE OF CREAM	MICROSCOPIC COUNT		DESCRIPTION OF SAMPLE
			yeasts	*oidia*	
		days			
1	2.7	7	12,000,000	500,000	Low acid; slightly stale
2	3.7	3	450,000	270,000	Low acid; clean flavor
3	4.0	4	820,000	215,000	
4	4.1	7	280,000	2,630,000	Medium acid; slightly stale
5	4 6	4	100,000	680,000	Clean flavor; low acid
6	4 7	4	650,000	130,000	Clean flavor; low acid
7	4 9	5	670,000	940,000	
8	5.3	3	130,000	20,000	Medium acid; clean flavor
9	5 4	3	440,000	340,000	Composite of 13 batch samples
10	5 5		1,600,000	230,000	Medium high acid; not appreciably stale
11	5.8		4,400,000	420,000	Acidity 0.65
12	6 0	6	4,500,000	950,000	Medium acid; clean flavor
13	6.3	4	500,000	145,000	
14	6.5		850,000	90,000	Acidity 0.82
15	6.6		760,000	75,000	First grade
16	6 8	2	140,000	−5,000	Acidity 0.65
17	6 9	3	370,000	15,000	Acidity 0.81
18	7.2	6	200,000	860,000	Medium acid; clean flavor; lumpy
19	7.8	3	600,000	15,000	Acidity 0.89.
20	8.0		800,000	150,000	First grade; acidity 0.89
21	8.6		1,650,000	170,000	Second grade
22	8.7		910,000	50,000	First grade; acidity 0.84
23	8.7	3	2,600,000	150,000	Whey cream.
24	10.3		1,000,000	85,000	Acidity 0.78

All of the remaining plants belong to the centralizer class, receiving sour cream, some of which contained more or less off flavors. This cream was divided into first and second grade, each grade being churned separately. Samples of cream and butter of both grades were secured during the months of June, July and August, 1921, from each of these plants, the yeast count on the cream varying from 140,000 to 13,550,000 and the oidia count from 60,000 to 5,250,000. The oxidizability value was high on all the samples of cream examined, averaging from 43.8 to 76.3 for the first grade samples and from 45.7 to 86.8 for the second grade samples. The values on the butters averaged from 2.6 to 6.7 for the first grade and from 3.4 to 8.9 for the second grade samples. With the exception of the results from plant no. 13, the average oxidizability value was higher on the second grade than on the first grade samples from each plant, respectively.

TABLE 17

Showing increase in amino nitrogen and ammonia as per cent of total nitrogen on cream samples sent through mail and containing no preservative

SAMPLE NUMBER	DAYS HELD IN MAIL	AMINO NITROGEN AND AMMONIA AS PER CENT OF TOTAL NITROGEN		INCREASE
		A	B	
1	3	7.9	12.3	4.4
2	3	10.5	13.4	2.9
3	4*	9.2	13.5	4.3
4	4*	11.5	15.7	4.2
5	3	7.6	13.2	5.6
6	3	8.9	11.0	2.1

* Two days in ice box after received.

When the samples from each plant are arranged according to ascending values for amino nitrogen and ammonia as per cent of total nitrogen on the cream, it is observed that the first and second grades are separated. With only two exceptions, sample no. 5, from plant no. 8, and sample no. 6, from plant no. 10, the second grade creams have a higher figure for amino nitrogen and ammonia as per cent of the total nitrogen than the first grade creams from the corresponding plant. The significance of this fact is that in samples of cream which, according to the judgment of cream graders, will produce an inferior quality of butter, there are present increased amounts of decomposition products measurable by chemical means.

Table 15 shows the maximum and minimum figure for first and second grades of cream from each plant. It is evident from these results that different cream graders working under different conditions will have different standard qualities as measured by the amino nitrogen and ammonia as per cent of the total nitrogen, for separating first and second grade cream. The standard any one grader will have will depend primarily upon the kind of cream he receives and the grade of butter he desires to manufacture.

TABLE 18

Showing results on authentic samples of milk from individual cows

NUMBER	QUANTITY OF MILK	PERIOD IN LACTATION	TOTAL NITROGEN	AMINO NITROGEN AND AMMONIA AS PERCENT OF TOTAL NITROGEN
	lbs.	*months*	*per cent*	
1	12.9	4	0.504	2.2
2	29.0		0.420	2.3
3	8.5	10	0.460	2.9
4	11.0	7	0.415	3.3
5	18.6	4	0.443	3.0
6	8.5	10	0.471	3.6
7		4	0.448	2.7
8	(mixed sample from 2 cows)		0.437	2.4
9	9.5	2	0.392	2.7
10		2	0.415	3.2
11	12	2	0.521	2.6
Average				2.8
Maximum				3.6
Minimum				2.2

That these samples of cream containing the higher percentage of decomposition products actually produced inferior butter is shown by the fact that the average score on the second grade samples in every case is lower than on the first grade samples. In a general way, the amino nitrogen and ammonia as per cent of the total nitrogen on the butter agrees with that on the cream from which the butter was made. The fact that there is not a strict correlation between cream and the resulting butter may be attributed to the details of manufacture, particularly the amount of starter added and the thoroughness of washing out the buttermilk. It is noticeable, however, that there is a wide difference between the results on the high scoring butters from plants nos. 1 and 2, and the results on the butters from the centralizing plants. The highest figure on the high grade butters, scoring 93 to 94, was 1.8, while on the remaining samples with the lower scores the results varied from 2.5 to 7.2 for first grade and from 3.5 to 7.5 for second grade butters.

The above results show that the amino nitrogen and ammonia as per cent of the total nitrogen gives a good indication of the quality of a given sample of cream for butter making. While the above recorded samples were being collected at plants no. 3 and no. 8, more samples of cream were taken from individual cans from farmers delivering their cream at known intervals. The results of the examination of these samples are shown in table 16, the samples being arranged according to increasing values for amino nitrogen and ammonia as per cent of the total nitrogen. This figure is not correlated with the age of the cream or the microscopic count of yeasts and oidia. It seems that the temperature at which cream is held is a more important factor than time in controlling decomposition.

In order to show the approximate rate of increase of amino nitrogen and ammonia under the conditions encountered in this work, duplicate portions of the cream samples containing no preservative, collected at plants no. 6, no. 7 and no. 13, were forwarded to Washington. Column A, table 17, represents the condition of sample at the time it was sampled at the plant, and column B at the time the samples were examined at Washington, the number of days the samples were held being shown in column 2. The average increase of the amino nitrogen and ammonia under these conditions was found to be about 1 per cent of the total nitrogen for each day the samples were held.

Table 18 shows the amino nitrogen and ammonia as per cent of the total nitrogen on 11 authentic samples of milk from individual cows. Samples nos. 1 to 10, inclusive, were from

Holstein cows milked three times a day and the samples were taken at the mid-day milking. Picric acid and acetic acid were added to the milk within 30 minutes of the time the milk was drawn and all solutions were filtered within two and one-half hours. The cows were being fed on a balanced ration of shorts, grain, cottonseed meal, silage, etc., and a small amount of pasturage. Sample no. 11 was from the morning milking of a Jersey cow fed approximately as the above but being milked only twice a day. The amino nitrogen and ammonia as per cent of the total nitrogen on these samples varied from 2.2 to 3.6, the average being 2.8.

SUMMARY.

Representative samples of cream and butter from thirteen different creameries were examined and it was found that the second grade cream contained a greater percentage of the total nitrogen present as amino nitrogen and ammonia than the first grade cream from the corresponding plants. This value averaged from 1.6 to 9.6 on cream producing first grade butter and 8.1 to 12.6 on cream that produced second grade butter. The results on the corresponding butters varied from 0.8 to 6.3 for the first grade and from 4.7 to 6.7 for the second grade samples. The butter from the cream containing the smaller amounts of amino nitrogen and ammonia as per cent of the total nitrogen scored from 93 to 94, while there was a general decrease in score on the butters from the cream having the higher value. The oxidizability value varied from 0.4 to 6.7 on the first grade butter and from 3.4 to 8.8 on the second grade butter, being higher, in general, on samples having the lower scores. Eleven authentic samples of fresh milk from individual cows gave values for amino nitrogen and ammonia as per cent of the total nitrogen varying from 2.2 to 3.6.

A STUDY OF THE ACTION OF CERTAIN BACTERIA, YEASTS AND MOLDS ON THE KEEPING QUALITY OF BUTTER IN COLD STORAGE[1]

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The development of the practice of cold-storing butter, manufactured during the Spring and early Summer, for sale during the Winter months has resulted in much work being done to determine the factors which influence the keeping quality of butter in cold storage; for, to the consumer, butter is as old as it tastes, whether it is a week old or six months old is immaterial to him, and if the butter has deteriorated in flavor it means a consequent depreciation of its commercial value.

Sayer, Rahn and Farrand 1908 (23) reviewed the literature relative to the keeping qualities of butter and Rahn and his co-workers 1909 (18) stated "It may and possibly is the type of microörganism present that is of importance, and the enzyme or disintegration products therefrom." Rogers and co-workers 1912 (20) stated "Butter frequently undergoes marked changes, even when stored at very low temperatures. These changes are more marked as the acidity of the cream from which the butter is made increases." Brown 1915 (3) concluded that the casein in butter during storage is slowly broken down into amino acids and ammonia. Dyer 1916 (4) stated "The production of off flavors so commonly met with in cold storage butter is attributable to a chemical change expressed through a slow oxidation progressing in some one or more of the non-fatty substances occurring in the butter. The extent of the chemical change is directly proportional to the quantity of acid present in the cream from which the butter was prepared." Hammer 1917 (7) reviewed the literature upon the production of fishy flavor in milk and butter and stated that *Bact. ichthyosmius* failed to produce fishiness when inoculated into butter. Washburn and Dahlberg 1917 (25) concluded that little if any relationship existed between the bacteria, the acidity and the score of the butter. Russell and Hastings 1920 (22) stated "In general it may be said that any and all types of organisms in the cream affect the keeping quality of the butter, to a greater or less extent, in an unfavorable manner, while the lactic bacteria seem to be the least injurious of all organisms." Hunziker 1920 (12) and Redfield and Stocking 1921 (19) agree that the quality of the cream largely governs the keeping quality of the butter in storage. Bouska and Brown 1921 (2) stated "The deterioration of butter is mainly the result of physical or biochemical causes. An indirect part may be played by microorganisms." Hammer 1921 (10) discussing butter flavors stated, "When butter is held in storage it may go rancid, fishy, metallic, unclean, or any one of a number of other flavors. The temperatures usually used for the storage of butter are so low that the growth of microörganisms is very unlikely, and it is now believed that the deterioration in flavor is due to slow chemical change." Fryhoffer 1922 (5) stated "One thing commonly agreed upon is that acid in cream is essential to the development of fishy flavor." As a result of work carried out at the Iowa State College, Mortensen 1922 (16) stated "Butter made from ripened cream deteriorates faster than either butter made from sweet cream or from sweet cream and starter, but—where low ripening was employed, the ripened butter at the end of a two months cold storage period was about of the same quality as the sweet cream butter and the sweet cream and starter butter." The lack of agreement as to the cause of deterioration of butter in cold storage led to the work herein described.

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[1] A summary of work carried out in partial fulfilment of the requirements for the Degree of Doctor of Philosophy, Iowa State College.

STATEMENT OF THE PROBLEM

The object of the work carried out was to determine the action of certain bacteria, yeasts and mold on the keeping quality of butter in cold storage. Bacteriological studies were made of the numbers and flora of the raw sweet cream and of the pasteurized sweet cream, and of the butter made therefrom, to seek to determine if any of these were a factor in the keeping quality of the butter in cold storage, and also serve as a check upon the other experiments. To determine the influence of the acidity of the cream the pasteurized sweet cream was divided into several portions and starter added and churning experiments made with cream of different acidities, both with and without the addition of various microörganisms. As the enzymes in the cream were not destroyed at the pasteurization temperature of 145°F. for twenty-five minutes it was sought to determine if the enzymes produced or other disintegration products of the bacteria were a factor in the keeping quality of the butter in cold storage. The starters used were prepared from *Streptococcus lactis* and *Streptococcus paracitrovorus* (8) as it was hoped that the use of cultures, which give a good flavor and aroma, without rapid acid development, would result in the production of butter with exceptional keeping qualities.

METHODS USED

The raw sweet cream delivered at the Iowa State College was pasteurized at 145°F. for twenty-five minutes and treated as follows:

1. Pasteurized sweet cream, acidity 0.14 to 0.21.
2. Pasteurized sweet cream with 10 per cent starter added, not ripened.
3. Pasteurized sweet cream, starter added, ripened to serum x 0.0063.
4. Pasteurized sweet cream, starter added, ripened to an acidity 0.50 to 0.61.

Lots 2, 3, and 4 were divided into two or more portions of 110 to 140 pounds each, and to one or more duplicates before churning a pure culture of the microörganisms to be tested was added. The material added consisted of 50 to 100 cc. milk culture, seventy-two hours old, plus the scraped off seventy-two hour old growth on two whey agar slants. The incubation was at room temperature. Every effort was made to standardize workmanship in manufacturing the butter. The moisture content was kept as near 16 per cent as practicable and the salt content ranged between 1.5 and 2.1 per cent. Bacteriological studies were made of the cream before churning and of the butter when manufactured and when finally scored. The butter was packed in ten pound tubs and stored for from six to seven months at −6°F. The bacteria used were, in addition to those in the starter, (*S. lactis* and *S. paracitrovorus*).

Bacterium ichthyosmius (7).

Peptonizing coccus. Digested milk in from two to four days, at 20°C. The mold used was *Oidium lactis*, as this is the mold usually found in dairy products.

Owing to the unsatisfactory condition of the classification of dairy yeasts, it is not possible to give definite names to the organisms used, but the following was used as a basis for the series of the experiments.

1. Forming regular white colonies on whey agar.
    - A. Lactose fermenters (9).
    - B. Common white.

Three types of common white yeasts were used in these experiments.

- A. Large oval yeast, makes milk alkaline in from eighteen to twenty-one days at 20°C.
- B. Large oval yeast, sweet curdles milk in from eleven to seventeen days at 20°C.
- C. Large oval yeast, spore-forming, inert in milk.

2. Forming spreading colonies on whey agar.
    - A. Mycoderma. Inert in milk.
    - B. Rapid liquefying yeasts. Liquefy milk in from two to three days at 20°C.
3. Pink yeasts.

Whey agar was used for plating cream to which starter had been added and the butter manufactured therefrom. Whey agar plus 1 cc. 1 per cent tartaric acid was used for estimation of yeasts and molds in cream and butter. Beef infusion agar was used for plating raw sweet cream, pasteurized sweet cream and the butter manufactured therefrom, as it was found to give higher counts than the whey agar since there are types, mainly micrococci, that will not grow on the latter medium. The bacteria were differentiated into various groups by the litmus milk tube method. The acidity of the butter was estimated by dissolving 10 grams in 35 cc. ether and 10 cc. alcohol and, using phenolphthalein as indicator, titrating with tenth-normal sodium hydrate solution. All counts reported are total plate counts.

RESULTS OBTAINED

Data relative to the acidity, the bacterial count and the types of bacteria found in the raw and pasteurized sweet cream are given in table 1. There were 28 lots of cream studied during the period from June to November, 1922. The cream was pasteurized at 145°F. for twenty-five minutes.

In the raw cream the high bacterial counts and the predominance of *S. lactis* will be noticed. When the acidity of the cream reached 0.20 and over, *S. lactis* formed 80 per cent or over of the total flora. There was no definite relationship between the flora of the raw cream and its acidity when the acidity was 0.18 or less, nor between the total bacterial count and the acidity. This is to be expected since the acidity depends on the acid-producing organisms present, and whether their environment is suitable or not, whereas the total count is the sum of several different types. Rennet-acid digesting micrococci and proteolytic types were present to the extent of approximately 1 per cent each in the raw cream; approximately 2 per cent of the flora consisted of *Bact. viscosum*, *Ps. fluor. liquefaciens*, *Eythrobacillus prodigiosus* and members of the coli-aerogenes group. From 50 to 200 *Oidium lactis* was found in each lot of raw cream and from 60 to 3000 yeasts. These yeasts were of the same general types as those used in the inoculation experiments.

It is evident that the cream after pasteurization contains relatively few organisms as compared with the original count, but these counts are higher than are usually considered to be present in pasteurized sweet cream. In 28 experiments the average pasteurization efficiency was 99.55 per cent, which is slightly lower than the efficiency of 99.93 per cent which was previously reported (6). The difference may be due to the media used; in the previous work the pasteurized sweet cream was plated on whey agar; and this did not permit various micrococci to grow, thus giving lower counts and consequent higher pasteurization efficiency. The typical *S. lactis* type was not found

TABLE 1

Acidity, bacterial count and types of bacteria found in raw and pasteurized sweet cream

(Summary of results obtained from 28 experiments

(Raw sweet cream)

	ACIDITY	BACTERIA PER CUBIC CENTIMETER—MILLIONS	PER CENT TYPE					
			A	B	C	D	E	F
Average	0.18	210	71	14	5	14	4	2
Maximum	0 21	388	96	33	22	50	31	17
Minimum	0 14	65	32	0	0	0	0	0

Pasteurized sweet cream

	BACTERIA PER CUBIC CENTIMETER—THOUSANDS	EFFICIENCY OF PASTEURIZATION	PER CENT TYPE				
			C	D	E	F	Y
		per cent					
Average 0.17	957	99.55	34	56	8	2	3
Maximum, 0 20	4,100	99.93	91	94	47	23	11
Minimum 0 13	185	98.54	0	13	0	0	0

A = *S. lactis*. B = *S. lactis var maltigenae*. C = Slow *S. lactis* type. D = Acid-forming, non-coagulating type. E = Alkali-forming type. F = types inert in milk. Y = gram positive micrococci producing yellow pigment. Column Y is included under Column D since they are acid-forming non-coagulating. Column B is included under column A since *S. lactis var maltigenae* belongs to the *S. lactis* group. The organisms included under slow *S. lactis* are so-named for want of definite knowledge of this group. They slowly reduce litmus milk and finally coagulate it after from 4 to 8 days.

in the pasteurized cream, and since it was present in the sweet cream butter, it is probable that the cells surviving pasteurization were missed in the dilutions used, or suffered injury during pasteurization and showed an abnormal lag phase, and were included in the slow *S. lactis* group. *S lactis* var. *maltigenae* was not found in the pasteurized cream nor in the butter, so it seems evident that it does not survive a pasteurization temperature of 145°F. for twenty-five minutes. The main surviving types were the slow *S. lactis* and the acid-forming, non-coagulating types. In this latter group were identified *S. paracitrovorus* and lactic acid producing, non-citric acid fermenting Gram positive streptococci, which included a thermophilic type which grew best at 45°C., grew well at 37°C. and poorly at 20°C. There were also found two types of Gram positive micrococci, easily differentiated because one produced yellow pigment and one did not on the media used. The percentage of the yellow pigment-forming type tended to increase with decreasing bacterial counts. They were not found in the raw cream, probably owing to the high dilution used (1 to 1,000,000).

The alkali-forming group, which according to Ayers and his co-workers (1) are primarily soil organisms, largely decreased in number during pasteurization, but increased in relative amount. No member of this group was found in 12 out of the 28 experiments. The group of bacteria inert in litmus milk largely decreased in number during pasteurization, but held their relative percentage of the flora. They were found in 8 out of 28 experiments. The aerobic spore-forming bacteria were not identified in the pasteurized cream, but were found in some of the butter when taken out of cold storage. They were probably missed in the high dilutions used for placing the cream (1 to 10,000). No molds nor yeasts were found in the pasteurized cream. Lund (14) and Thom and Ayers (24) have shown that *Oidium lactis* will not survive heating at 145°F. for ten minutes, and the number of yeasts originally present in the raw cream was too small to draw any conclusion as to their ability to survive pasteurization.

Data relative to the action of *Bact. ichthyosmius* and a peptonizing coccus on the keeping quality of butter cold-stored for six months at –6°F. are given in table 2. Although the butters to which proteolytic bacteria were added decreased somewhat in score, the decrease was not enough to indicate that the addition of the proteolytic bacteria was an important cause of deterioration in butter in cold storage. *Bact. ichthyosmius* was inoculated into cream ripened to 0.50 per cent and into cream to which starter had been added, but not ripened. The results indicate that the acidity of the cream did not favor the production in the butter of undesirable flavors as a result of the action of proteolytic bacteria.

TABLE 2

Action of proteolytic bacteria on the keeping quality of butter in cold-storage

SCORING	OF EXPERIMENTS	ACIDITY OF CREAM	MICROÖRGANISM INOCULATED	SCORE
Initial	2	0 50	A	92.75
Final				91.75
Initial	1	0 50	Check experiment	92.5
Final				92.5
Initial	3	0 22	A	92.18
Final				91.83
Initial	1	0 22	Check experiment	92.0
Final				92.0
Initial	3	0.50	B	93.00
Final				92.17
Initial	1	0.50	Check experiment	92.5
Final				92.5

A = *Bact. ichthyosmius.* B = *Peptonizing coccus* (peptonizing coccus was a Gram positive peptonizing micrococcus isolated from raw sweet cream).

Data relative to the action of various types of yeasts on the keeping quality of butter made from cream ripened to varying acidities and cold stored for six months are given in table 3. Considering that flavor and aroma are qualities in butter that are difficult to give a definite value to when scoring at different intervals, it will be seen that the scores of the butter made from the uninoculated cream and the inoculated cream agree very well. Although in many experiments there was some decrease in score, a study of the figures show that the yeasts were not a factor in the keeping quality of the butter in cold storage, and that their action was not influenced by the acidity of the cream since the yeasts were inoculated into cream of varying acidities and in several cases the check experiments decreased in score more than the butter made from inoculated cream. Some types of yeasts were more resistant to the adverse conditions than others. *Pink yeast* and *Mycoderma* did not survive while 80 to 98 per cent of the lactose fermenting types (*T. cremoris* and *T. sphaerica*) and *Common White* types died off in cold storage. The most resistant type was the Digesting yeast of which an average of 43 per cent survived. From 10 to 25 per cent of the yeast count per cubic centimeter in cream was found per cubic centimeter in butter, except with the *pink yeast* which apparently found conditions adverse from the start.

Date relative to the action of (a) *Oidium lactis* and yeasts and (b) *Oidium lactis* alone, inoculated into cream at varying acidities, in relation to the keeping quality of butter in cold storage are given in table 4.

Although there was a decrease in score of the butter, it is evident that the combination of yeasts and *Oidium lactis*, or *Oidium lactis* alone did not cause deterioration in cold storage, and that the acidity of the ripened cream did not favor deterioration by these microörganisms. These results confirm those of Rogers 1909 (21) who was unable to produce fishy butter by the inoculation of *Oidium lactis* into cream, although O'Callaghan 1907 (17) had claimed that *Oidium lactis* produces fishiness in butter. The fact that no *Oidium lactis* survived in the cold storage butter shows that it was in an unfavorable environment.

Data relating to the bacterial count, flora and score of sweet cream are given in table 5. The data shows that organisms of the various groups can survive in butter that has been cold stored six months at −6°F. The acid-forming, non-coagulating type formed 70 per cent of the flora at the initial scoring and 80 per cent at the final scoring. It is evident that *S. paracitrovorus*,

TABLE 3

Action of yeasts on the keeping quality of butter in cold-storage

SCORING	NUMBER OF EXPERIMENTS	ACIDITY OF CREAM	MICROÖRGANISM INOCULATED	NUMBER IN CREAM	NUMBER IN BUTTER	SCORE	INCREASE OR DECREASE IN SCORE
Initial*	6	0.27	Common white yeast	10,600	930	92.83	
Final					33	92.25	−0.58
Initial	3	0.28	Check experiments			93.17	
Final						92.83	−0.34
Initial	6	0.44	Common white yeast	28,800	6,100	91.79	
Final					450	91.21	−0.58
Initial	5†	0.44	Check experiments			92.10	
Final						90.90	−1.20
Initial	2‡	0.56	Common white yeast	34,400	6,000	91.00	
Final					110	91.50	+0.50
Initial	6	0.50	Lactose-fermenting yeasts	35,900	4,020	92.00	
Final					840	91.75	−0.25
Initial	4	0.51	Check experiments			92.12	
Final						91.64	−0.48
Initial	5	0.30	Digesting yeast	33,200	8,540	91.70	
Final					3,680	91.90	+0.20
Initial	2	0.31	Check experiments			92.00	
Final						91.50	−0.50

Initial	4	0 24	Pink yeast	32,750	1,200	92.12	
Final					None	91.87	−0.35
Initial	2	0 24	Check experiments			92.00	
Final						92.00	±0.0
Initial	5	0.31	Mycoderma	7,260	860	92.50	
Final					None	92.80	+0.30
Initial	2	0.29	Check experiments			92.50	
Final						92.25	−0.25

* All figures given are the average figures for the experiments carried out.

‡ These experiments were duplicates of experiments averaged in 5†. Three types of common white yeast were used in the experiments, but as the results secured with them were essentially alike, they are included under one heading in above table.

TABLE 4

Action of Oidium lactis and yeasts and Oidium lactis alone on the keeping quality of butter in cold storage

SCORING	NUMBER OF EXPERIMENTS	ACIDITY OF CREAM	MICROÖRGANISM USED	NUMBER IN CREAM	NUMBER IN BUTTER	SCORE	INCREASE OR DECREASE IN SCORE
Initial ..	7	0.48	M plus L	33,360 Y	8.100 Y	92.70	
				1.710 M	234 M		
Final					820 Y	90.93	−1.77
Initial ..	7	0.48	Check experiments			92.57	
Final						91.00	−1.57
Initial ..	3	0.44	M	2.730 M	1.470 M	92.33	
Final					None	92.18	−0.15
Initial ..	3	0.44	Check experiments			91.83	
Final						91.69	−0.14
Initial ..	2	0.57	M	3.150 M	1.700 M	92.00	
Final					None	90.50	−1.50
Initial ..	2	0.57	Check experiments			92.00	
Final ...						90.75	−1.25

M = *Oidium lactis.* Y = Yeasts.

TABLE 5

Bacterial count, flora and score of sweet cream butter at initial and final scorings

SCORING	BACTERIA PER CUBIC CENTIMETER—THOUSANDS	PER CENT TYPE					
		S. lactis	Slow S. lactis	Non-coagulating acid forming	Alkali forming	Inert	Peptonizing
Initial*............	167	0	20	70	6	4	0
Final*............	141	6	8	80	2	1	3

	ACIDITY OF CREAM	BACTERIA PER CUBIC CENTIMETER IN BUTTER—THOUSANDS		ACIDITY OF BUTTER		SCORE	
		Initial	Final	Initial	Final	Initial	Final
Average*..........	0.18	167	141	1.08	1.17	91.71	91.76
Maximum.........	0.21	630	600	1.40	1.50	93.0	93.0
Minimum..........	0.14	54	30	0.90	1.00	90.5	90.0

* Average of 19 experiments.

lactic-acid producing, non-citric acid fermenting streptococci and various types of micrococci can resist pasteurization and cold storage conditions, and thus show themselves to be very resistant to unfavorable conditions. *S. lactis* was not found in the butter when manufactured, but was found after cold storage. The butter manufactured from the sweet cream retained 5 to 30 per cent of the bacteria per cubic centimeter of the cream; usually between 20 to 30 per cent was found; and 35 to 100 per cent of the bacteria per cubic centimeter originally in the butter was found after the cold storage period. It is evident from the scores that the butter showed excellent keeping quality, having a slightly higher average score when it came out of cold storage than it had when it went in and that the flora of the pasteurized sweet cream did not cause deterioration in cold storage.

Data relative to the bacterial count per cubic centimeter of the cream, buttermilk and butter; the acidity of the cream and butter, and the score of the butter at the initial and final scorings are given in table 6. The number of bacteria per cubic centimeter as determined by the plate method, in the cream to which starter had been added, had no definite relation to the acidity of the cream. This is to be expected since the production of acidity is a function: (a) of the ratio of *S. lactis* to *S. paracitrovorus*, (b) the rate of acid production of the *S. lactis* inoculated. The buttermilk, except in a few instances, showed a higher bacterial count per cubic centimeter than the cream did, but no definite relationship existed. The following causes are suggested as to why a higher count should be obtained per cubic centimeter in the butter-milk than in the cream; (a) removal of the butterfat containing comparatively few bacteria, (b) breaking up of bacterial clumps by agitation during churning. The flora of the cream to which starter had been added was found to consist of *S. lactis* and *S. paracitrovorus*, the *S. lactis* forming 90 to 100 per cent of the flora. Other organisms must have been present, but were probably missed owing to the high dilution necessary for plating (1 to 1,000,000).

The butter made from cream to which starter had been added and (a) not ripened and (b) ripened to varying acidities, retained

TABLE 6

Bacteriological count of the cream, buttermilk and butter, acidity of the cream and butter and score of butter at initial and final scorings

ACIDITY OF CREAM	BACTERIAL COUNT				ACIDITY OF BUTTER		SCORE	
	Cream—millions	Butter milk—millions	Butter					
			Initial—thousands	Final—thousands	Initial	Final	Initial	Final
Sweet cream plus 10 per cent starter (8 experiments)								
Average 0 28...	278	336	4,100	95	1.30	1.32	92.56	92.12
Maximum, 0.35...	530	610	8,500	285	1.50	1.50	94.0	93.0
Minimum 0 22...	77	90	650	3	1.20	1.20	91 0	90.0
Sweet cream plus 10 per cent starter plus added microörganisms (23 experiments)								
Average 0.27...	256	302	3,250	91	1.28	1.32	91.94	91 84
Maximum, 0.35...	510	600	7,800	460	1.45	1.50	93 5	94.0
Minimum 0.22...	70	78	600	3	1.20	1.15	91.0	90.0
Sweet cream ripened to serum × 0.0063 (22 experiments)								
Average, 0.44...	196	211	2,813	69	1 55	1.68	92.34	91 00
Maximum, 0.46...	510	540	12,400	336	2.00	2.20	93.5	92.5
Minimum 0.42...	67	73	520	1	1.35	1.50	91.5	88.0
Sweet cream ripened to serum × 0.0063 plus added microörganisms (17 experiments)								
Average, 0.44...	105	127	1,170	28	1.64	1.75	92.03	91.41
Maximum, 0.46...	160	205	1,850	86	2.20	2.20	93.0	93.5
Minimum 0.42...	63	78	440	2	1.40	1.40	91.0	88.0
Sweet cream ripened to from 0.50 to 0.61 (7 experiments)								
Average, 0.55...	232	282	2,650	52	1.96	1.96	92 21	90.57
Maximum, 0.61...	550	730	5,300	270	2.20	2.40	92.5	91.5
Minimum 0.50...	123	144	960	3	1.75	1.75	91.5	90.0
Sweet cream ripened to from 0.50 to 0.61 plus added microörganisms (16 experiments)								
Average, 0.53...	319	391	3,305	78	1.81	1.96	92.09	91.62
Maximum, 0.61...	800	960	7,300	305	2.35	2.35	93.0	93.0
Minimum 0.50...	74	87	630	2	1.45	1.50	90.5	90.0

per cubic centimeter from 0.5 to 2 per cent of the bacteria per cubic centimeter of the cream, generally about 1 per cent. The flora of the butter was found to consist of *S. lactis* and *S. paracitrovorus*, the *S. lactis* forming 70 to 100 per cent of the flora, usually over 90 per cent. The dilution used for plating (1 to 10,000) probably accounts for other organisms not being found. The average dying off of bacteria during the six months cold storage at −6°F. was over 98 per cent. This, considering the larger initial bacterial count of the butter, is in marked contradistinction to the results obtained with the sweet cream butter. When taken out of cold storage, the sweet cream butter often had a higher bacterial count per cubic centimeter than the butter made from cream to which starter had been added. This seems to show that the normal flora of pasteurized cream find an acid environment unfavorable; also the utilization of the lactose by *S. lactis* and *S. paracitrovorus* may be a factor. The flora of the butter when taken out of cold storage was found to consist chiefly of *S. lactis* and the acid-forming non-coagulating types, and usually contained from 100 to 2000 yellow pigment forming micrococci per cubic centimeter. *S. paracitrovorus* was usually present. The per cent of *S. lactis* varied from 0 to 100 per cent, but was usually present in some amount. The acid-forming non-coagulating type varied from 0 to 100 per cent; usually the lower the bacterial count of the butter the greater the percentage of this type.

The butter made from sweet cream to which starter had been added, but not ripened, had a higher initial score than the sweet cream butter. The score decreased on the average 0.44 points whereas the sweet cream butter increased its score on the average 0.05 points, yet the final score was higher by 0.36 points than the sweet cream butter. This shows that this method of butter manufacture is practicable, and it has the advantage that the butter has a flavor which makes it more desirable.

The average score of the butter made from the uninoculated cream, ripened to serum x 0.0063 was 92.34 points. This type of butter lost 1.34 points in cold storage, thus having a lower average score by 0.76 points than the sweet cream butter, but the average score of 91.0 points after six months cold storage shows better keeping quality than is usually credited to this type of butter.

The average score of the butter made from the uninoculated cream ripened to 0.50 to 0.61 was 92.21 points. This type of butter lost 1.64 points during six months cold storage, and the corresponding decrease for the butter made from inoculated ripened cream was 0.47 points. The final average score of 90.57 points for the uninoculated butter and 91.62 points for the inoculated butter shows better keeping quality than is usually credited to this type of butter, and also that the addition of the microörganisms did not cause deterioration. It is also evident that while lactic acid may be a factor in deterioration it is not a direct cause of it.

That lactic acid may aid as a factor in deterioration is shown by the fact that several churnings decreased from a 92 to an 88 point score, while the check churning made from the sweet cream without the addition of starter retained its score or only slightly decreased in score. It is this fact that has led to the association of acidity of cream with deterioration of butter in cold storage, and the increasing demand for sweet cream butter for storage purposes. A proof that *S. lactis* and *S. paracitrovorus* are not a direct cause of deterioration is shown by the keeping quality of the butter made from cream to which starter had been added but not ripened.

The acidity of the butter increased as the acidity of the cream increased, but the individual range is so wide, that it seems that the acidity of the butter is not in proportion to the acidity of the cream, but is influenced by other factors, such as the treatment during manufacture.

CONCLUSIONS

1. There was an average pasteurization efficiency of 99.55 per cent when sweet cream was pasteurized at 145°F. for twenty-five minutes.
2. The bacterial count of the ripened cream had little or no relation to the acidity of the cream.

3. The bacterial count per cubic centimeter of the butter made from ripened cream had no definite relation to the bacterial count per cubic centimeter of the ripened cream.

4. The butter made from ripened cream retained per cubic centimeter from 0.5 to 2 per cent of the bacteria per cubic centimeter of the ripened cream, generally about 1 per cent.

5. The butter made from pasteurized sweet cream retained per cubic centimeter from 5 to 30 per cent of the bacteria per cubic centimeter of the pasteurized sweet cream, generally between 20 to 30 per cent.

6. From 95 to 99 per cent of the bacteria of the ripened cream died off during six months cold storage, generally from 98 to 99 per cent.

7. The average decrease in the bacteria in the butter made from pasteurized sweet cream during six months cold storage was approximately 20 per cent, the maximum decrease was 65 per cent, the bacterial count per cubic centimeter of some butters did not show any decrease.

8. Resistant strains of *S. lactis*, slow *S. lactis* type, *S. paracitrovorus*, lactic acid forming, non-coagulating, non-citric acid fermenting streptococci, various types of micrococci, inert types, alkali-forming types and proteolytic types lived over in the butter, cold-stored for six months.

9. Taking the acidity of the butter as a criterion, there was little or no detectable hydrolysis of the butterfat during six months cold storage.

10. The acidity of the butter increased as the acidity of the cream increased, but there was no definite relation between the acidity of the butter and the acidity of the cream.

11. Proteolytic bacteria, various types of yeasts found in dairy products, and *Oidium lactis* were added to ripened and unripened cream containing starter before churning and were found not to be a significant factor in the deterioration of butter in cold storage for six months at −6°F.

12. There was no evidence that the enzymes produced during the growth of the microörganisms or the disintegration products produced on the death of the microörganisms affected the keeping quality of the butter in cold storage.

13. Sweet cream butter was found to keep well in cold storage and for the most part to retain its original score. One hundred per cent of the lots of butter scored 90 and over both when put into and taken out of cold storage.

14. Butter made from sweet cream plus 10 per cent starter, unripened, was found to have good keeping quality and to have a slightly higher average score when taken out of cold storage than the churnings made from pasteurized sweet cream. One hundred per cent of the butters scored 90 and over, both when put into and taken out of cold storage.

15. Butter made from sweet cream ripened with a mixture of *S. lactis* and *S. paracitrovorus* showed good keeping quality in cold storage, but marked deterioration of occasional churnings occurred. One hundred per cent of the butters scored 90 and over when put into cold storage, and 83 per cent of these butters scored 90 and over when taken out of cold storage.

16. Where deterioration of butter occurs in cold storage it is not due to the normal flora of pasteurized cream, nor to *S. lactis* or *S. paracitrovorus*, nor to the lactic acid formed during the ripening of cream by a starter.

17. The occurrence of erratic decreases in score of butter made from ripened cream, which rarely occurs when the cream is not ripened, suggests that the deterioration of butter made from ripened cream is due to some as yet undetermined cause, which may be aided in its action by the lactic acid produced during the ripening of the cream.

18. The quality of the cream when delivered at the creamery is probably the main factor that determines the keeping quality of butter in cold storage.

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A STUDY OF THE RELATION OF THE COMPOSITION OF THE MIX TO THE QUALITY OF THE FINISHED ICE CREAM[1]

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This investigation was undertaken to study the relation of the percentage of butterfat, milk solids not fat, and total milk solids in the mix to the quality of the frozen ice cream.

Several series of mixes were prepared, varying in composition as shown in table 1.

The materials used in the preparation of the mixes were cream containing forty per cent butterfat, skimmed milk, superheated condensed skimmed milk, water, cane sugar, gelatin, and vanilla extract. The same amounts of sugar (12 per cent), gelatin (0.5 per cent), and vanilla extract (0.5 per cent) were used in all mixes, the other materials were varied to give the desired composition.

The cream, skimmed milk, and condensed milk were pasteurized.[2]

The mixes were frozen in an ordinary brine freezer of fifty quarts capacity. The temperature of the brine ranged from 4° to 12°F. and the time of freezing from twelve to twenty minutes. The brine was pumped through the freezer until the temperature of the mix reached 26° to 27°F. or until the mixture began to freeze, then shut off. The ice cream was allowed to whip until the maximum swell was secured, as determined with a Mojonnier overrun tester.

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[1] This article is based on a thesis presented to the Faculty of the Graduate School of the University of Illinois by A. S. Ambrose in partial fulfillment of the requirements for the degree of Master of Science in Dairy Husbandry.

[2] The mixes were not homogenized or viscolized. A separate study of these processes and their influence upon the composition of ice cream is now in progess.

Samples of the finished ice cream were taken in each case, when the ice cream was half drawn from the freezer. These were drawn into small cartons, placed in a hardening room and held until time of examination. The first sample of each lot was examined between two days and one week after freezing, and the succeeding samples at intervals of seven to ten days apart. A number of the samples were held as long as forty-six days.

TABLE 1

Composition of mixes

MIX NUMBER	PERCENTAGE BUTTERFAT	PERCENTAGE M.S.N.F.	PERCENTAGE CANE SUGAR	PERCENTAGE GELATIN	PERCENTAGE TOTAL SOLIDS
1	8	6	12	0.5	26.5
2	8	10	12	0.5	30.5
3	8	12	12	0.5	32.5
4	8	14	12	0.5	34.5
5	8	18	12	0.5	38.5
6	10	6	12	0.5	28.5
7	10	10	12	0.5	32.5
8	10	12	12	0.5	34.5
9	10	14	12	0.5	36.5
10	10	18	12	0.5	40.5
11	12	6	12	0.5	30.5
12	12	10	12	0.5	34.5
13	12	12	12	0.5	36.5
14	12	14	12	0.5	38.5
15	12	18	12	0.5	42.5
16	14	6	12	0.5	32.5
17	14	10	12	0.5	36.5
18	14	12	12	0.5	38.5
19	14	14	12	0.5	40.5
20	14	18	12	0.5	44.5

In some cases as many as four mixes of one composition were prepared and frozen at different times, in other cases only one mix of a certain composition was prepared and frozen. Fifty-three separate mixes, a total of four hundred and fifty gallons of ice cream, were prepared and frozen.

BASIS OF COMPARISON

It was necessary to formulate a definition of a good commercial ice cream in order to have a uniform basis of comparison. A definition acceptable to all is manifestly impossible because of individual preferences. However, certain general qualities seemed essential. These characteristic qualities may be considered under the headings of texture, resistance, body, flavor, and stability.

Flavor refers to the taste imparted by the ingredients; for example, the flavor of the condensed milk used, or the taste which may develop during storage, such as old or stale flavors, condensed milk flavor, or "lactose" flavor. The term "lactose" is used to designate a mildly sweet, somewhat saline flavor that frequently occurs in ice cream which contains a comparatively high milk sugar concentration.

Texture refers to the size, shape and arrangement of the particles or the structure of the ice cream. An ideal texture is one which is perfectly smooth or entirely free from all graininess.

Resistance is the property of the ice cream to resist melting when placed in the mouth. An ice cream is undesirable when it melts down like snow, so also is one which is so resistant as to be soggy. The degree of resistance is relative and can best be described as too little, good, or too much.

Body refers to the total organized substance or the mass of ice cream as a whole. It is dependent upon the texture and resistance. It may be described as light, good, heavy, or soggy.

Stability is the property of the ice cream to retain the desirable qualities. A freshly frozen product may seem to possess all the desirable qualities and yet serious defects may develop in flavor, body, or texture after it has been held in storage, or in dealers' cabinets for a few days.

"Sandiness" refers to a condition which sometimes occurs in ice cream, and which is generally conceded to be caused by crystallization of milk sugar.[3] Such ice cream contains many particles resembling fine sand which dissolve in the mouth with difficulty. "Sandy" ice cream must not be confused with "grainy" ice cream. The term "grainy" refers to a condition caused by the crystallization of comparatively large particles of ice which dissolve in the mouth readily.

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[3] Sandy crystals in ice cream: Their separation and identification, Harper F. Zoller and Owen E. Williams, Journal of Agricultural Research, vol. xxi, no. 10, August 15, 1921.

The terms used in judging the ice creams were as follows:

TEXTURE	RESISTANCE	BODY	FLAVOR
Very smooth (velvety)	Too much	Soggy	Condensed milk
Smooth	Good	Heavy	Lactose
Coarse	Lacking	Good	Old or stale
Very coarse		Light	

The samples were examined by four judges and a summary of the criticisms of 150 samples is presented in the accompanying tables.

RELATION OF THE PERCENTAGE OF TOTAL MILK SOLIDS TO TEXTURE, RESISTANCE, BODY, AND FLAVOR OF ICE CREAM

Table 2 contains the criticisms of the ice creams with the samples arranged according to the total milk solids content.

It is evident from this table that the ice creams which contained a low total milk solids content (14.0 to 20.0 per cent) were unsatisfactory in every way as they were more or less coarse in texture, lacking in resistance, and light in body. The ice creams with a high total milk solids content (28.0 to 32.0 per cent) were also unsatisfactory in that they were entirely too resistant and had heavy or soggy body.

The quality of the ice creams which had the same total milk solids content was not the same, for example, series 8, 9, and 10 all contained 22 per cent total milk solids yet the texture varied from coarse to smooth, the resistance from lacking to good, and the body from light to good. Similarly, there were differences in series 11, 12, and 13 with 24 per cent total milk solids, and in the series 14, 15, and 16 with 26 per cent total milk solids. There are likewise variations in series with high total milk solids, and in series with low total milk solids, although the variation in quality within each of these series is not as marked as in the series with a medium total milk solids content.

The data indicate that the quality of ice cream is dependent upon the kind of the milk solids more than upon the percentage of total milk solids, although a good quality of ice cream cannot be had with either a very low or a very high total milk solids content.

TABLE 2

Relation of percentage of total milk solids to texture, resistance, and body of ice cream

SERIES	PER CENT FAT	PER CENT M.S.N.F.	PER CENT T.M.S.	TEXTURE	RESISTANCE	BODY
1	8	6	14.0	Very coarse	Lacking	Light
2	10	6	16 0	Very coarse	Lacking	Light
3	8	10	18.0	Coarse	Lacking	Light
	12	6	18.0	Very coarse	Lacking	Light
4	10	10	20.0	Coarse	Lacking	Light+
	14	6	20.0	Very coarse	Lacking	Light
	8	12	20.0	Coarse	Lacking+	Light+
5	8	14	22.0	Smooth	Good	Good
	12	10	22.0	Coarse	Lacking	Light+
	10	12	22.0	Coarse+	Good	Good
6	10	14	24.0	Smooth	Good	Good+
	14	10	24.0	Coarse	Good−	Good−
	12	12	24.0	Smooth+	Good	Good
7	8	18	26 0	Very smooth	Good+	Heavy
	12	14	26.0	Smooth+	Good+	Heavy−
	14	12	26.0	Very smooth	Good+	Heavy
8	10	18	28.0	Very smooth	Too much	Heavy+
	14	14	28.0	Very smooth	Too much	Heavy−
9	12	18	30.0	Very smooth	Too much	Soggy
10	14	18	32.0	Very smooth	Too much	Soggy

RELATION OF THE PERCENTAGE OF MILK SOLIDS NOT FAT TO TEXTURE, RESISTANCE, BODY, AND FLAVOR OF ICE CREAM

A study of table 3 shows that the ice creams which contained 6 per cent milk solids not fat were very coarse in texture, lacking in resistance, and light and snowy in body in every instance.

They were also partially churned. The small percentage of milk solids not fat, seemingly, did not offer sufficient internal resistance to prevent churning during the freezing process.

The ice creams which contained 18 per cent milk solids not fat had velvety texture, very heavy or soggy body, and were entirely too resistant. It would seem, that as far as texture, resistance, and body are concerned 6 per cent milk solids not fat produce a quality of ice cream of one extreme and 18 per cent the other extreme. Between these extremes there is a more or less gradual change in these qualities as the percentage of milk solids not fat increases. The texture changes from coarse to very smooth or velvety, the body from light to heavy, and the resistance becomes

TABLE 3

Relation of the percentage of milk solids not fat to texture, resistance, body, and flavor of ice cream

SERIES	PER CENT M.S.N.F.	PER CENT B.F.	TEXTURE	RESISTANCE	BODY
A	6	8	Very coarse	Lacking	Light
	6	10	Very coarse	Lacking	Light
	6	12	Very coarse	Lacking	Light
	6	14	Very coarse	Lacking	Light
B	10	8	Coarse	Lacking	Light
	10	10	Coarse	Lacking	Light
	10	12	Coarse	Lacking	Light+
	10	14	Coarse	Good−	Good−
C	12	8	Coarse	Lacking	Light+
	12	10	Coarse+	Good	Good
	12	12	Smooth	Good	Good
	12	14	Very smooth	Good+	Heavy
D	14	8	Smooth	Good	Good
	14	10	Smooth	Good	Good+
	14	12	Smooth +	Good+	Heavy−
	14	14	Very smooth	Too much	Heavy−
E	18	8	Very smooth	Good	Heavy
	18	10	Very smooth	Too much	Heavy+
	18	12	Very smooth	Too much	Soggy
	18	14	Very smooth	Too much	Soggy

greater. This tendency is apparent in each series although the butterfat content remained constant.

The data indicate that a certain proportion of milk solids not fat is necessary to produce smooth texture, good resistance, and desirable body regardless of the percentage of butterfat present. Added milk solids not fat beyond this amount and up to a certain point bring about an increased smoothness in texture, greater resistance, and heavier body. However, there is a limit beyond which further increases in milk solids not fat are of little or no value in this respect.

The flavor of all the ice creams was very good when first frozen. Those which contained 12, 14, and 18 per cent milk solids not fat frequently developed a condensed milk or "lactose" flavor in from two to three weeks after they had been placed in storage. These flavors rarely developed in the ice creams which contained less than 12 per cent milk solids not fat.

Sandiness often developed in the ice creams which contained 14 to 18 per cent milk solids not fat, while it was evident in only two cases in the ice creams which contained less than 14 per cent. This condition usually did not appear until after the ice cream had been in storage for about two or three weeks and was more often apparent after three weeks.

RELATION OF THE PERCENTAGE OF BUTTERFAT TO TEXTURE, RESISTANCE, BODY, AND FLAVOR OF ICE CREAM

Table 4 contains the same data arranged in series with variations in the percentages of butterfat.

It is evident that in some series increased percentages of butterfat had no effect upon the quality of the ice creams, while in other series as little as 2 per cent increase brought about a change. The criticisms of texture of the ice creams in series A, B, and E were the same within each series although the percentage of butterfat ranged from 8 to 14 per cent. However, there were variations in series C and D within each series. The 12 per cent milk solids not fat ice creams (series C) varied from coarse to very smooth, and 14 per cent milk solids not fat ice creams (series D) varied from smooth to very smooth. The criticisms of resistance and body show quite similar variations. A probable explanation for this is as follows:

As stated under the discussion of the relation of milk solids not fat, a certain proportion of milk solids not fat seems necessary to produce a good quality of ice cream. With less than this proportion any increase in the amount of butterfat, from 8 to 14 per cent, has little or no effect upon the quality of ice cream. When the proportion of milk solids not fat is sufficient, an increased percentage of butterfat acts very much the same as increased milk solids not fat, that is, produces smoother texture, greater resistance, and more desirable body. In other words, the two have a complimentary value within certain limits. As in the case

TABLE 4

Relation of the percentage of butterfat to texture, resistance, body, and flavor of ice cream

SERIES	PER CENT FAT	PER CENT M.S.N.F.	TEXTURE	RESISTANCE	BODY
A	8	6	Very coarse	Lacking	Light
	8	10	Coarse	Lacking	Light
	8	12	Coarse	Lacking+	Light+
	8	14	Smooth	Good	Good
	8	18	Very smooth	Good+	Heavy
B	10	6	Very coarse	Lacking	Light
	10	10	Coarse	Lacking	Light+
	10	12	Coarse+	Good	Good
	10	14	Smooth	Good	Good+
	10	18	Very smooth	Too much	Heavy
C	12	6	Very coarse	Lacking	Light
	12	10	Coarse	Lacking	Light+
	12	12	Smooth	Good	Good
	12	14	Smooth+	Good+	Heavy−
	12	18	Very smooth	Too much	Soggy
D	14	6	Very coarse	Lacking	Light
	14	10	Coarse	Good−	Good−
	14	12	Very smooth	Good+	Heavy
	14	14	Very smooth	Too much	Heavy−
	14	18	Very smooth	Too much	Soggy

of milk solids not fat, there is an upper limit beyond which an increase in the butterfat content, seemingly, does not improve the quality of ice cream.

It is evident from these data that there is a lower and an upper limit wherein the butterfat influences the quality of ice cream. The lower as well as the upper limit is dependent upon the percentage of milk solids not fat. Between these limits a difference in quality is evident with a smaller increase in the percentage of butterfat when the milk solids not fat content is increased.

In addition to the effect upon texture, resistance, and body the butterfat influences the flavor of ice cream. Here also, the milk solids not fat have an influence. With the low milk solids not fat content (6 per cent) the increase in fat content from 8 to 14 per cent, did not improve the flavor. In all other cases increased percentages of butterfat produced ice cream with richer flavor. The ice creams which contained 14 per cent butterfat were extremely rich.

CONCLUSIONS

The quality of ice cream with respect to texture, body, and resistance is dependent more upon the kind of milk solids than upon the total milk solids. The milk solids not fat are more essential than the butterfat in this respect.

In general a good commercial ice cream can be made with from 10 to 12 per cent milk solids not fat and 8 to 14 per cent butterfat. An excellent quality of ice cream was obtained with 12 per cent butterfat and 12 per cent milk solids not fat.

A high percentage of milk solids not fat (14 to 18 per cent) is conducive to a condensed milk or "lactose" flavor and also to a "sandy" condition where condensed milk is used to supply the milk solids not fat in ice cream.

A high percentage of butterfat produces a richer flavored ice cream.

A GREENISH-BLACK DISCOLORATION OF CHOCOLATE ICE CREAM

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An ice cream manufacturer in New York, during the winter of 1922–1923, was troubled with a greenish-black discoloration that appeared sporadically in his chocolate ice cream. The discoloration was described by the manufacturer as spots slightly greenish in color. These spots developed in five or six cans out of fifty and were not confined to any special ice cream mix. The time required for these spots to appear varied from one to ten days. They usually developed in the hardening room, although in other cases, they developed only after the ice cream was put in the retailer's cabinet. No excessive numbers of bacteria were found by the manufacturer, and no molds were in evidence. Tin and copper were absent in these spots, and a trace of iron was present in quantities comparable to that found in the normal colored chocolate ice cream.

THE CHEMISTRY OF THE DISCOLORATION

Examination of a 5-gallon can of this ice cream sent to this Station showed a ring of greenish-black color in the chocolate around the extreme outside of the ice cream next to the can. By removing large pieces of ice cream from the can it became evident that the greenish-black spots on the ice cream matched identically in pattern the rust spots on the can. No spots could be found where the can was well tinned or in the ice cream at any other place than where it was exposed to rusty places. The flavor of these spots was extremely fishy. Since Rogers, Berg, Potteiger and Davis[1] have found that metallic salts, especially iron, accelerate the production of fishy flavor in butter, the evidence seemed to indicate that iron was one of the essentials for the production of the greenish-black discoloration.

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[1] L. H. Rogers, W. N. Berg, C. R. Potteiger, B. J. Davis. Factors Influencing the Flavor of Storage Butter. U. S. Dept. of Agric., B. A. I. Bul. 162. 1913.

Some of the ice cream was repacked into a new container and on the surface of the ice cream were placed strips of tinned iron with and without rust spots. Some of the strips were dipped in a concentrated sodium chloride solution to hasten the formation of rust. Part of the ice cream so treated was held continuously at –10° to 0°F. and part of it was softened daily at a warm temperature. Within twenty-four hours the discoloration appeared on the chocolate ice cream exposed to rusty iron dipped in salt brine. In four or five days it appeared by the strip of tinned iron which had exposed rust spots, but it required about two weeks for a trace of the color to become noticeable by exposed iron well scoured and free from rust. The alternate softening and hardening hastened the production of the color and increased its intensity.

To obtain more conclusive evidence of the part played by iron in the production of this color a few drops of a 10 per cent solution of chemically pure ferric chloride were added to a limited area of frozen chocolate ice cream and a greenish-yellow discoloration appeared instantly which changed in a few minutes to greenish-black.

This discoloration appeared in no other ice cream than chocolate. Hence, the chemical with which the iron was combined to produce the greenish-black color must be contained in cocoa. Analyses given in chemical books treating in plant products, as well as those obtained through the courtesy of two chocolate and cocoa manufacturers, gave two classes of compounds whose properties are such that they may have been responsible for this color, namely, the proteins and the tannins. Cocoa contains 10 to 20 per cent protein and 2 to 5 per cent tannin. The ferric salts of tannins are blue, green, black or any combination of these three colors. They have been used as the basis of several inks.

When a few drops of a 10 per cent solution of ferric chloride were added to 10 cc. of a 5 per cent solution of cocoa the solution became intensely black. The cocoa used was obtained from the manufacturer in whose ice cream the greenish-black color appeared. The solution of cocoa was made in boiling water in order to obtain a high degree of solution.[2] When the black cocoa solution was filtered most of the color filtered out, but the filtrate was also very black. To the clear brown filtrate from a 5 per cent cocoa solution a few drops of ferric chloride were added and a heavy bluish black precipitate appeared. When this was filtered the filtrate was also black. The compounds in the cocoa that combined with the iron were therefore soluble in water while the greenish-black color was due to both soluble and insoluble compounds.

American standard horse hide powder was prepared according to the method described in the methods of analyses as published by the American Association of Agricultural Chemists. The filtrate of a 5 per cent cocoa solution was treated with this hide powder as if a tannin determination of the filtrate was being made. The hide powder removed the tannin from solution and when ferric chloride was then added to the filtrate no greenish-black color developed.

From the work with cocoa filtrates it became evident that the acidity or alkalinity of the solution as well as the degree of dilution changes the character of the color developed and may entirely prevent its appearance. To learn if the hide powder had interfered in any other way with the development of the color, an equal quantity of cocoa filtrate was added to that treated with hide powder and ferric chloride then produced the characteristic color. The production of a greenish-black color or precipitate with iron and the combination with hide are two of the distinguishing characteristics of tannins.

There are two classes of compounds in cocoa that contain nitrogen; the proteins and theobromine. For this reason the total nitrogen content of the cocoa as determined was not calculated as protein due to the error that would be introduced by the theobromine. The cocoa contained 3.44 per cent nitrogen.

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[2] The mixture of cocoa with boiling water is not a true solution, but the various constituents exist in true solutions, colloids, and suspensions.

More than half of the nitrogen-containing material was not dissolved in boiling water, but filtered out. One hundred cc. of a 5 per cent cocoa solution were filtered, and 20 cc. of the filtrate were found to contain 0.0136 gm. nitrogen. In other words, 1.36 per cent nitrogen passed through the filter paper. Ferric chloride was added to some of the cocoa solution and the filtrate, representing 1 gram of cocoa, was found to contain 0.0109 gram nitrogen, which represents 1.09 per cent nitrogen in the cocoa that passed into the filtrate. This difference of 0.27 per cent nitrogen represents some protein that was precipitated by the iron, and protein occluded by the ferric tannate precipitate. The theobromine being soluble in water in such small quantities could not account for this reduction in filterable nitrogen resulting from the addition of ferric chloride to the cocoa solution if it was precipitated by ferric salts.

COCOAS VARY IN PRODUCING DISCOLORATION

The conditions favorable to the production of this discoloration of chocolate ice cream are prevalent in the ice cream business so that it is surprising that this difficulty has not been more generally encountered. To obtain information on this point the ability of various grades of cocoa to produce this discoloration was determined.

Through the courtesy of a cocoa manufacturer four different grades of cocoa were obtained. One of them was a high grade "Dutch Process" cocoa and the other three represented their highest, lowest, and medium grade cocoas. Two samples of cocoa were purchased at a grocery store in Geneva; one retailing for 35 cents per pound, and the other for 10 cents. The ice cream manufacturer having difficulty with the greenish-black color supplied us with samples of two different cocoas he was using. The ability of each of these eight samples to produce the discoloration in chocolate ice cream was determined by the addition of a few drops of 10 per cent solution of ferric chloride to 10 cc. of a 5 per cent solution of cocoa. It was found that only three out of the eight cocoas tried could produce the greenish-black color. They were: the "Dutch Process" cocoa, the cocoa retailing at 35 cents per pound which was the product of the company manufacturing "Dutch Process" cocoa, and one of the samples submitted by the ice cream manufacturer. All of these cocoas appeared to be of fine quality.

Why do some of the cocoas produce this color with iron while others do not? It was suggested by a manufacturer of cocoa through correspondence that it (the greenish-black color) may be due to an alkaloid or to the Dutch Process cocoa having a free alkali present. The cocoa filtrates were first tried with phenolphthalein and found to be acid. Tests with Brom-thymol-blue made by the addition of a small quantity of cocoa filtrate to a neutral solution containing the indicator showed that those cocoas which produced the discoloration had a slightly alkaline pH value (about 7.2), while the others were slightly acid (about 6.6). By the addition of $\frac{N}{10}$ NaOH the pH value of all the filtrates was brought to a slightly alkaline condition and the greenish-black color was produced by all when a solution of ferric chloride was added. The tannins producing this color were, therefore, present in all the samples of cocoa, but are in active form only in the alkaline condition. Subsequent changing of the pH to slightly acid did not affect the production of color.

PREVENTING THE DISCOLORATION

Two methods of preventing the appearance of this discoloration are obvious. The most effective method is the use of cocoa not capable of producing the color. This can be determined, without trying the cocoa in ice cream to see if the discoloration appears, by the addition of a solution of ferric chloride to the cocoa solution as previously described. The other method is the prevention of iron in soluble form from coming in contact with chocolate ice cream. This can be accomplished by the use of well-tinned ice cream cans or by the complete lining of all ice cream cans with exposed iron with the paraffined cardboard can liners that are on the market. The development of the discoloration can be checked if not entirely stopped when cans with exposed iron are used without can liners by a thorough scrubbing to remove all rust, followed by prompt drying.

SUMMARY

An outbreak of a greenish-black discoloration of chocolate ice cream has been described. It was caused by ferric tannate which was formed by the soluble iron or rusty cans reacting with the tannins in the cocoa. Not all cocoa will produce this discoloration with ferric salts. Three samples of cocoa that gave the discoloration had an alkaline pH value, while five that did not give the color were acid in reaction. The appearance of this discoloration in chocolate ice cream can be prevented by the use of well-tinned or paper lined cans or by the use of cocoa that is not capable of producing it.

NORMAL GROWTH OF THE JERSEY COW

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The normal birth weight of Jersey males and females and the normal growth of the heifers until two years of age has been determined at this station, by Eckles (1, 2). It is well known by dairymen, however, that growth continues for several years. As dairy cattle are bred to calve at approximately two years, the lactation (3) following seriously interferes with normal growth after that age. Still lactation is a normal function of the dairy cow and it is of considerable value to determine the normal growth with age of the lactating dairy cow.

For the past twenty years the American Jersey Cattle Club has required that the weights of all cows completing a Register of Merit record be reported. The object of this paper is to report the results of a study of this data based on the weights of 15680 animals at various ages throughout the entire productive life of the dairy cow. These weights should be typical of the registered cows of the Jersey breed as they include both the American and Island strains.

The average weights for the various ages as shown in table 1 were computed from the individual records with the aid of a correlation table (table 2). It should be pointed out in this connection that the ages represent the time the animals started on test, while the weights were sent to the club at the completion of the record. It would appear that a correction of one year should be made. However, cows on test generally do not gain in weight during the lactation period and therefore the weights at the beginning and close of the test do not vary materially. The weights of many of the cows were estimated but as there is no apparent reason for bias, it is thought that the large number of records reported overcomes this difficulty to a large extent.

From table 2 it will be seen that there were a few cows tested under eighteen months of age at the start of the test. These 26 animals weighed an average of 710 pounds. There were also 1001 yearlings (18 to 24 months) weighing an average of 767 pounds. The largest number of animals come in the class from 2 to 2.5 years with the number of animals tested gradually decreasing as they become older. The oldest animal tested was eighteen years old while a second one reached the advanced age of over seventeen years.

TABLE 1

Data on the growth of Jersey cattle

AGE	NUMBER OF ANIMALS INCLUDED	AVERAGE WEIGHT
years		*pounds*
1.5	26	710
1.5–2	1001	767
2–2 5	3155	808
2.5–3	1449	836
3–3 5	1523	872
3 5–4	1122	888
4–4 5	1171	916
4 5–5	916	930
5–6	1692	938
6–7	1235	945
7–8	965	952
8–9	621	957
9–10	364	962
10–11	208	957
11–12	108	968
12–13	64	956
13–14	32	961
14–15	14	1036
15–16	9	975
16–17	4	963

It will be seen from the figure that the Jersey cow reaches the mature weight of approximately 960 pounds at about eight years of age. It might be noted that Eckles (2) gives the mature weight of the American type Jersey as 902 pounds, a weight considerably below that shown in the figure. This discrepancy does not appear to be due to experimental error as inferred from

TABLE 2

Correlation table of age and weight of Jersey cattle

WEIGHT CLASSES	AGE CLASSES IN YEARS																				TOTAL
	Under 1.5	1.5–2	2–2.5	2.5–3	3–3.5	3.5–4	4–4.5	4.5–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	13–14	14–15	15–16	16–17	
lbs.																					
400–450								1													1
450–500		2																			2
500–550	1	6	8	2																	17
550–600		14	9	4	1	1															29
600–650	4	94	124	23	14	4	4	1		2	1										271
650–700	6	107	205	64	30	13	1	1	5	3	3		1								439
700–750	9	205	485	176	91	53	30	15	31	13	11	4	6	2			1				1, 132
750–800	3	215	583	192	169	94	69	45	69	45	39	25	5	6	1	2	1				1, 563
800–850	2	188	837	377	345	224	204	142	199	146	102	64	31	22	13	2		1	3	1	2, 903
850–900	1	90	410	258	280	242	209	151	267	183	112	75	44	19	13	5	4				2, 363
900–950		54	333	222	328	244	272	212	422	274	217	143	78	58	29	22	7	3	1	2	2, 921
950–1, 000		19	89	72	123	117	166	128	246	201	169	88	72	29	12	18	8	2			1, 559
1, 000–1, 050		6	56	48	99	91	141	136	269	231	185	142	76	41	22	12	9	1	4		1, 569
1, 050–1, 100			10	4	25	19	42	44	95	66	61	34	20	16	5	1		3	1		446
1, 100–1, 150		1	3	5	15	12	26	28	59	45	48	28	23	10	6		2	2			313
1, 150–1, 200			2		1	4	6	4	16	14	6	11	5	4	2	2				1	78
1, 200–1, 250			1	1	2	3	1	7	9	7	9	5	2	1	5			2			55
1, 250–1, 300						1			4	1											6
1, 300–1, 350									1	3	1	2									7
1, 350–1, 400											1		1								2
1, 400–1, 450											1										
1, 450–1, 500				1						1											2
1, 500–1, 550								2													2
Total.....	26	1, 001	3, 155	1, 449	1, 523	1, 122	1, 171	917	1, 692	1, 235	965	621	364	208	108	64	32	14	9	4	15, 680

the smoothness of the curve and from the probable error which is only about 3 pounds at eight years.

The distribution of the animals by weight classes at different ages is also clearly shown in table 2 and needs little explanation. The mode of the class under 1.5 years is at the weight class of 700 to 750 pounds, that of the next class 750 to 800 pounds, while the mode of the two year olds comes in the 800 to 850 pound class. The mature animals are fairly evenly distributed between the 900 to 1050 pound classes.

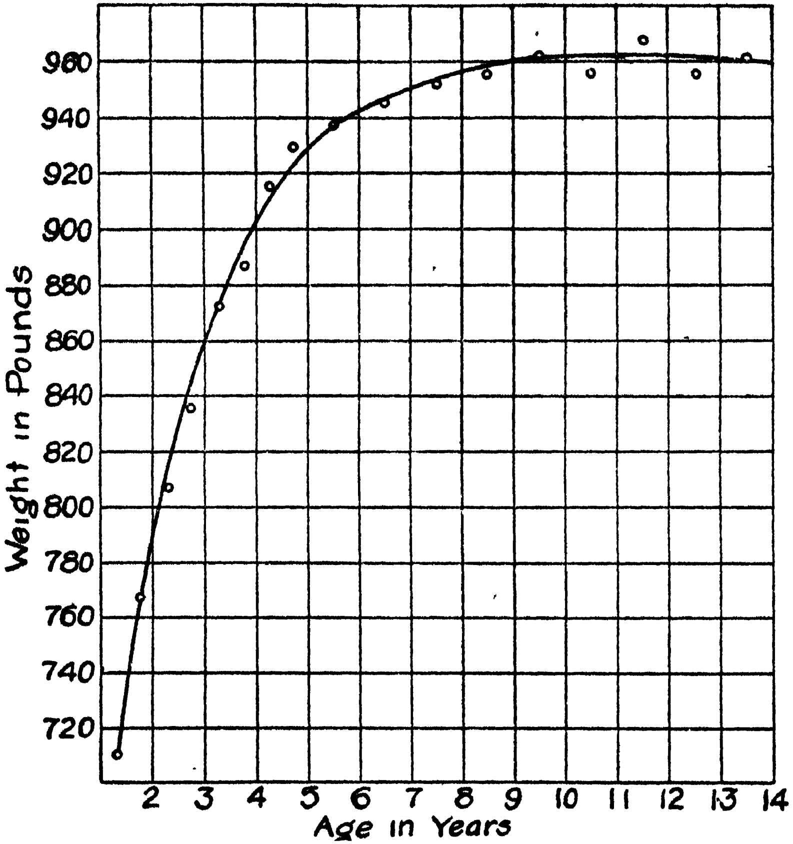

FIG. 1. AGE-WEIGHT CURVE OF THE JERSEY COW

A theoretical matter might be mentioned in connection with the growth curve.[1] The curve can be represented by an exponential equation of the form

$$X = A\ (1\text{-}e^{-kt})$$

Where X is the weight of the animal at any age t, and A is the mature weight which is seen from the graph to be about 960 pounds. It may be assumed that growth is due to a certain limiting substance produced at the time of conception which is gradually utilized. As soon as this limiting substance or growth impulse is completely utilized, growth ceases.

The weight of the animal may be taken as a measure of the amount of this growth substance used up, and the difference between the mature weight, 960 pounds, and the weight at any age t, a measure of the amount of substance or growth impulse left unused. This equation indicates that the percentage at which this unused substance is used up is the same from year to year. Thus the difference between 960 and the weight at different ages is as follows:

AVERAGE AGE	WEIGHT	DIFFERENCE	PER CENT OF DIFFERENCE
years	*pounds*	*pounds*	
2 5	817	143	
3 5	879	81	56 6
4 5	922	38	46.9
5.5	938	22	57.8
6.5	945	15	68.1
7.5	952	8	53.3
8.5	957	3	37.5

In other words, the percentage decline of the growth limiting substance or growth impulse is approximately constant.

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[1] A theoretical discussion is given in the Journal of General Physiology, Vol. v, No. 4, p. 445–449.

FACTORS INFLUENCING PERCENTAGE OF FAT IN MILK

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The explanation of the variation observed in the fat content of milk from individual cows or herds from one period to another has engaged the attention of investigators for many years. The consensus of opinion is that the fat content depends upon the breed, the individual within the breed, the degree of fatness at time of parturition, and the stage of lactation; and that neither feed nor management can be so varied as to change more than temporarily the percentage of fat.

Since it was established by our work[1] at Brownsville, Texas, that the percentage of fat is lowered by the feeding of prickly pear and that the greater the quantity of pear fed the greater the reduction in fat content, we have from time to time conducted other experiments at the Beltsville station with a view to explaining the results obtained in the feeding of pear, also to find out the influence of other feeds and of certain methods of management.

The outstanding characteristics of prickly pear so far as the analysis is concerned are the high water and mineral contents. It was thought likely that one or both of these constituents were responsible for the lowering of the fat content. Accordingly experiments were conducted[2] in which cows consumed varying quantities of water, with the result that the percentage of fat was found to be unaffected.

The mineral matter of prickly pear differs from that of other green materials mainly in having a large content of calcium and magnesium and a relatively low content of phosphorus. These constituents were investigated separately in a series of experiments which are reported in this paper.

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[1] Hoard's Dairyman, 1916

[2] Jour. Agri. Research, April 24, 1916.

THE EFFECT OF CALCIUM

To find out the influence of calcium, four cows were fed the regular ration consisting of grain, hay, and silage in comparison with the same ration with 1 pound of steamed bone meal added. Two of the cows received the bone meal for twenty days, the check ration for twenty days, then the bone meal for another twenty days. The other two cows received the check ration for twenty days, then the bone-meal ration, and finally the check ration again. The results are seen in table 1.

TABLE 1

Average fat content of milk in experiment with bone-meal ration

	cow 17	cow 21	cow 23	cow 100
	per cent	*per cent*	*per cent*	*per cent*
Bone-meal ration..............	4.90	5.075		
Check ration....................	5.025	4.925	4.10	4.40
Bone-meal ration....................	5.175	5.025	4.325	4.55
Check ration........................			4.60	4.45
Difference attributed to bone-meal. . .	+0.012	+0.125	−0.025	+0.125

Three of the four cows showed an increase in per cent of fat when bone meal was fed, but the increase was so slight as to be within the range of experimental error. The conclusion that bone meal does not influence the per cent of fat is apparently justified.

Since bone meal contains phosphorus as well as calcium, and the pear has a low phosphorus content, it was thought best to get additional data in which calcium was fed in the form of a carbonate. In the nutrition investigations at this station three cows have been so fed as to admit of four comparisons between a ration containing limestone and one without limestone. In two cases the milk tested higher when limestone was fed and in two cases it tested lower. In view of these facts it was thought that a special experiment on the subject was unnecessary.

THE EFFECT OF LIBERAL MINERAL AND WATER

The next step was to try a combination in which both the water and minerals were lower in one ration than in the other. Two cows were fed a ration low in mineral, consisting of corn silage, cottonseed hulls, and a grain mixture composed of equal parts of corn meal, wheat bran, and cottonseed meal, with 1 per cent salt added. These cows were given only 75 per cent of the quantity of water which they would normally drink. Two other cows at the same time were fed a similar ration with one pound of bone meal added per cow per day, and were allowed all the water they would drink twice daily. At the end of twenty days the rations were reversed. See table 2.

TABLE 2

Average fat content of milk, in experiment with ration low in both minerals and water

	cow 14	cow 64	cow 51	cow 61
	per cent	*per cent*	*per cent*	*per cent*
Normal water, high mineral....	4 513	3.614		
Low water, low mineral.......	5 040	3.655	3.459	5 166
Normal water, high mineral.......... .	4 620	3 80	3 574	5 034
Low water, low mineral...........			3.460	5.090
Increase attributed to low water and low mineral............................	0 474	−0.052	−0.114	−0 094

In two cases the low water and low mineral apparently increased the per cent of fat and in two cases there was a decrease. The differences are slight except in one instance.

When cows ate prickly pear the total water intake was much in excess of the quantity normally consumed with any usual ration, so another experiment was conducted in which the cows were induced to take a supernormal quantity of water along with 1 pound of bone meal per cow per day, in comparison with the same cows receiving the normal quantity of water and no bone meal. Turnips were fed during one period in such quantities as it was thought would increase the normal water intake 10 to 20 per cent. Table 3 shows the results.

While the data in the two foregoing experiments are too meager to admit of definite conclusions, it appears that high water consumption coupled with high mineral content in the ration does not influence the per cent of fat in milk.

THE EFFECT OF MAGNESIUM

The next experiment with the mineral matter was to try the effect of adding some compound of magnesium to the ration, since as stated above the pear was high in this element. Magnesium carbonate was fed at the rate of 0.3 pound per cow per day in alternate ten-day periods, in each of which eight days were considered experimental. Each individual milking was tested for fat. The ration of grain, hay and silage remained the same throughout.

TABLE 3

Average fat content of milk, in experiment comparing normal water and low mineral with supernormal water and high mineral in the ration

	COW 33	COW 49	COW 67
	per cent	*per cent*	*per cent*
Normal water, low mineral	4.99	3.91	
Supernormal water, high mineral	4.72	4.17	4.07
Normal water, low mineral	5.15	4.37	4.11
Increase attributed to low water and mineral	0.35	−0.03	0.04

TABLE 4

Average fat content of milk, in experiment with feeding magnesium carbonate

	COW 460	COW 460
	per cent	*per cent*
Check ration	5.33	5.76
Magnesium carbonate	5.18	5.92
Check ration	5.28	6.23
Change attributed to magnesium carbonate	−0.125	−0.075

Cow 462 on check ration in the first eight-day period produced milk with an average fat content of 5.68 per cent; with magnesium carbonate added the milk tested 6.14 per cent; in the second check-ration period the test was 5.76 per cent. In this case the magnesium gave a higher testing milk, which is contrary to what would be expected.

This cow was continued on the experiment along with cow 460, and the further results by eight-day periods are shown in table 4.

It cannot be stated from this experiment that the magnesium carbonate affected the percentage of fat, as the differences observed are within the range of experimental error.

The results of feeding another compound of magnesium, epsom salt, at the rate of ½ to ¾ pound per cow per day to four cows showed a slight decrease for two cows and a small increase for two cows, as shown in table 5.

TABLE 5

Average fat content of milk, when epsom salt was fed

	COW 6	COW 7	COW 244	COW 249
	per cent	*per cent*	*per cent*	*per cent*
Epsom salt, ¾ lb	3.99	4.68		
Check ration	4.12	4.96	4.35	3.79
Epsom salt, ¾ lb	4.09	4.90	4.76	3.89
Check ration			4.69	3.89
Change attributed to epsom salt	−0.08	−0.17	+0.24	+0.05

It is realized that there are dozens if not hundreds of combinations in which the mineral matter might occur in the plant, every one of which might exert a different physiological effect upon the animal body. If the lowering of the fat content observed when prickly pear is fed is due to a particular mineral compound the difficulty in finding it will be appreciated in view of the fact that the different mineral combinations in the pear are unknown. For these reasons it has seemed best not to pursue the matter further.

EFFECT OF HIGH-PROTEIN FEEDING

It has been reported that high-protein feeding increases the percentage of fat in milk. To test the accuracy of this statement four cows, two Jersey and two Holstein, were fed large quantities of high-protein feeds, in comparison with a grain ration composed of hominy feed 100 pounds, ground oats 100 pounds, wheat bran 100 pounds, linseed oil meal 50 pounds, and cottonseed meal 50 pounds, which ration is here designated as "ordinary grain." The feeding was in periods of ten days. During certain periods three-fourths of the usual allowance of the ordinary grain ration was replaced by a high-protein feed. The first two days following the change in ration were discarded in the calculations, this length of time being allowed for the full effect of the change to become manifest. The figures given in table 6 therefore are averages for eight-day periods, calculated from weights and tests taken of each milking. Cow 227 received 10 pounds grain; 439, 9 pounds; 243, 15 pounds; and 466, 12 pounds. The high-protein feed varied from 6.8 to 11.2 pounds per cow daily.

TABLE 6

Average fat content of milk, in experiment with high-protein feeding

	COW 227	COW 439	COW 213	COW 446	ALL COWS
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
Ordinary grain	3.32	5.59	3.08	6.14	4.38
Three-fourths cottonseed meal	3.69	6.12	3.38	6.64	4.83
Ordinary grain	3.37	5.70	3.07	5.91	4.37
Three-fourths of linseed oil meal	3.50	6.10	3.51	6.22	4.67
Ordinary grain	3.51	5.46	3.02	5.30	4.16
Three-fourths of gluten feed	3.37	5.70	3.13	5.40	4.17
Ordinary grain	3.56	5.88	3.19	5.33	4.24
Three-fourths of linseed oil meal	3.43	5.86	3.24	4.99	4.16
Three-fourths of linseed oil meal	3.52	5.73	3.22	4.88	4.13
Three-fourths of linseed oil meal	3.58	5.72	3.32	4.90	4.20
Three-fourths of linseed oil meal	3.91	5.96	3.24	4.95	4.30

It will be observed by comparing high-protein periods with an average of the ordinary-grain periods immediate before and after, that in every instance an increase followed the use of the cottonseed meal; and the same is true of the first period in which linseed oil meal was fed. These results confirm those obtained in a previous experiment by R. R. Graves and L. S. Riford at this station, in which two cows were fed 4 to 6 pounds of the oil meals for short periods. Gluten feed had no uniform effect one way or the other, and this is also the case with the last four periods of linseed oil-meal feeding. Apparently the effect of these feeds on the test is not permanent and it is possible that at the time gluten feed was offered the previous effects had worn off and it was time for the test to drop.

Since the high-protein feeds affecting the test in this experiment are rich in oil as well as protein, the question arose as to whether the increase in percentage of fat was due to the protein or to the oil. Accordingly another experiment was conducted in which linseed oil was compared with linseed oil meal. Six cows were used. Three were fed the ordinary grain ration for ten days, then the same with 0.7 to 1.0 pound linseed oil per cow per day for ten days; and this was followed by another 10-day period the same as the first. The other three cows were fed the same, except during the second period when three-fourths of their grain was replaced by linseed oil meal. The first two days of each period was discarded in the calculations, so the figures given in table 7 are averages for eight days. Cows 434, 447, 460, 426, 439, and 468 received the following quantities of grain respectively; 12, 9, 13.5, 14, 10, and 12.6 pounds. Cows 434, 447, and 460 during the second period consumed respectively 0.8, 0.6, and 0.95 pounds of linseed oil daily.

TABLE 7

Average fat content of milk, when linseed oil and linseed oil meal were fed in comparison with ordinary grain ration

	COW 434	COW 447	COW 460	ALL COWS
	per cent	*per cent*	*per cent*	*per cent*
Ordinary grain	5.90	6.21	4.62	5.38
Ordinary grain plus linseed oil	6.05	6.31	5.21	5.73
Ordinary grain	5.51	5.53	4.57	5.10
	COW 426	COW 439	COW 468	ALL COWS
Ordinary grain	6.20	5.53	4.89	5.57
Three-fourths of linseed oil meal	6.24	6.26	5.06	5.75
Ordinary grain	5.88	5.37	4.67	5.32

In every case both the meal and oil brought about an increase in the test. Apparently the principal, if not the only, factor increasing the percentage of fat is the oil.

Since gluten feed is low in oil and linseed oil meal is high in oil the effect of these two feeds was compared to get further information on the effect of oil on the test. Six cows divided into groups were run for six ten-day periods. Cows 82, 237, 468, 93, 236, and 254 received respectively 8, 9, 8, 8, 9, and 8 pounds of grain per day. During the second period one-fourth of the grain of one group consisted of gluten feed, and one-fourth of the grain of the other group consisted of linseed oil meal. For the fourth and sixth periods the gluten feed and linseed oil meal made up three-fourths of the entire grain fed. Table 8 shows the results.

TABLE 8

Average fat content of milk, in experiment comparing gluten feed with linseed oil meal

	COW 82	COW 237	COW 468	ALL COWS
	per cent	*per cent*	*per cent*	*per cent*
Ordinary grain	3.95	3.60	4.71	4.06
One-fourth gluten feed	4.11	3.66	5.09	4.23
Ordinary grain	4.10	4.01	4.99	4.35
Three-fourths gluten feed	4.07	3.95	5.01	4.31
Ordinary grain	4.08	4.11	5.31	4.45
Three-fourths gluten feed	4.11	4.07	5.35	4.46
	COW 93	COW 236	COW 254	ALL COWS
Ordinary grain	4.89	3.65	3.51	3.94
One-fourth linseed oil meal	4.96	4.08	3.54	4.15
Ordinary grain	5.15	4.20	3.92	4.41
Three-fourths linseed oil meal	5.65	4.75	4.02	4.80
Ordinary grain	5.25	4.78	3.90	4.72
Three-fourths linseed oil meal	5.44	5.13	4.06	4.99

This experiment shows that the small quantities of either gluten feed or linseed oil meal did not affect the test. The larger quantities of gluten feed did not increase the percentage of fat in the milk, but the linseed oil meal did, though not to so great an extent as in some of the preceding experiments. Possibly this decreased effect is due to the smaller quantities of linseed oil meal fed to these cows.

In order to see how permanent the increase in test was, five cows were fed on a large quantity of linseed oil meal for 40 days, this being preceded and followed by periods or ordinary feeding. Cows 82, 220, 407, 462, and 468 received respectively 11, 13, 15, 11, and 10 pounds of grain per day. For forty days three-quarters of these quantities were linseed oil meal. In table 9 are shown the results of this experiment.

The average for all the cows shows that after ten days of high linseed oil meal feeding the percentage of fat returns to normal, though the reaction to such feeding is not at all uniform with the different individuals.

TABLE 9

Average fat content of milk, when cows were fed linseed oil meal in large quantity for a long period

	COW 82	COW 220	COW 407	COW 462	COW 468	ALL COWS
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Ordinary grain	4.21	3.80	5.96	6.38	5.77	5.08
Three-quarters linseed oil meal	4.41	4.09	6.13	6.88	5.71	5.30
Three-quarters linseed oil meal	4.11	3.74	6.09	6.66	5.40	5.03
Three-quarters linseed oil meal	3.93	3.85	5.97	6.84	6.08	5.07
Three-quarters linseed oil meal	4.20	3.80	6.20	6.51	5.61	5.06
Ordinary grain	4.08	3.89	6.22	6.76	5.32	5.03
Ordinary grain	4.08	3.75	6.38	6.87	5.54	5.10

EFFECT OF EXERCISE

In the experiments at this station to determine the effect of exercise upon production it was found that cows when they took exercise by walking three miles a day yielded milk containing a slightly higher percentage of fat than when they remained at rest. The details are given in tables 10, 11, and 12.

The investigation was followed up further by making tests of individual milkings of several cows when at rest and when exercised.

In order to solve the question conclusively a more extended test with six cows was made in which each individual milking was analyzed for fat.

Of the 11 cows in the above tables all showed an increase in test when changed from rest to exercise and a decrease when changed from exercise to rest, except in two instances out of

22 possible comparisons. In every case when the average test on exercise was compared with the average on rest, the exercise gave the richer milk. Also the mixed milk showed that exercise increased the test.

TABLE 10

Average fat content of milk from cows when exercising and when at rest, the tests being made of composite samples of milk for two days out of each 10-day period

	FIRST EXPERIMENT							
	Period	Cow 87	Cow 409	Cow 416	Cow 245	Cow 401	Cow 435	All cows
	days	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Rest......	50	3.38	6.03	5.25	4.17	6.22	5.36	4.76
Exercise..	50	3.64	6.22	5.84	4.30	5.62	5.33	4.92
	SECOND EXPERIMENT							
	Period	Cow 82	Cow 411	Cow 466	Cow 254	Cow 441	Cow 83	All cows
Rest......	40	3.86	4.67	4.91	3.33	5.25	4.58	4.42
Exercise.	40	3.86	4.78	5.64	3.47	5.18	4.65	4.55

TABLE 11

Average fat content of milk from cows when exercising and when at rest, the tests being made from selected individual milkings

	First group			
	PERIOD	COW 409	COW 416	BOTH COWS
	days	*per cent*	*per cent*	*per cent*
Rest.......	2	5.92	5.21	5.59
Exercise.	12	6.29	5.58	5.95
Rest...............	8	6.07	5.18	5.69

Second group

	PERIOD	COW 245	COW 401	COW 435	ALL COWS
	days	*per cent*	*per cent*	*per cent*	*per cent*
Exercise........	2	4.55	5.63	5.48	5.19
Rest......... ..	12	4.29	5.27	5.29	4.90
Exercise........	4	4.24	5.55	5.38	5.07

EFFECT OF HOT WEATHER

As a rule the composite milk supply from a large number of cows contains a smaller quantity of butterfat in summer than in winter. There are three possible factors having to do with lowering the test in summer-weather, feed, and recent freshening of cows. The herd maintained at the Dairy Division Experiment Station is one of the few which receives the same feed in summer as in winter and in which the cows freshen at all times of the year. For these reasons it offers exceptional opportunities for studying the effect of hot weather on the percentage of fat.

Ever since the dairy herd was established at this station accurate tests have been made regularly every month of each cow's milk. A two-day composite prepared by taking an aliquot portion of each milking is used for testing. To date there are 166 animals with at least one test in January and one in July. These two months were selected as representing the two extremes of temperature. Altogether 830 tests have been made in these two months. Some 426 calvings are represented, 179 of which occurred between the January and July tests, and 247 between July and January tests. A greater number received their first test in January than in July. It is evident, therefore, that in general the July tests were made later in the period of lactation and thus could not account for any lowering of the fat content

TABLE 12

Average fat content of milk from cows when exercising and when at rest, the tests being made from all milkings for six to ten days, each milking tested separately

	FIRST GROUP				
	Period	Cow 82	Cow 460	Cow 462	All cows
	days	*per cent*	*per cent*	*per cent*	*per cent*
Rest	6	4.54	4.88	6.10	5.25
Exercise	6	5.20	4.99	6.26	5.52
Exercise	10	5.26	4.74	5.78	5.28
Rest	10	4.73	4.70	5.35	4.97
	SECOND GROUP				
	Period	Cow 220	Cow 401	Cow 461	All cows
Exercise	6	4.59	4.94	6.03	5.07
Rest	6	4.30	5.05	5.83	4.95
Rest	10	4.24	4.93	5.42	4.80
Exercise	10	4.59	5.48	6.02	5.27

in summer. Since such lowering was not due to the feed, nor to the stage of lactation, it could only be due, apparently, to the hot weather of summer. Table 13 gives a compilation of these tests.

In preparing this table the tests for January and July were listed separately for each cow and an average test for each of the two months was obtained. From the averages thus secured the figures given in the table were prepared. They represent, therefore, averages in which the data from each cow receive equal weight regardless of whether the tests are for only two months or several.

TABLE 13

Effect of season on per cent of fat

BREED	NUMBER OF ANIMALS	NUMBER OF CALVINGS		NUMBER OF TESTS		AVERAGE OF TESTS		DIFFERENCE
		January to July	July to January	January	July	January	July	
						per cent	*per cent*	
Jersey..........	49	39	45	69	93	5.96	5.39	0.57
Holstein..........	41	54	48	106	126	3.66	3.62	0.04
Guernsey........	16	25	24	42	46	5.75	5.03	0.72
Grade Jersey.....	11	12	42	47	44	5.03	4.94	0.09
Grade Holstein...	15	19	15	33	40	4.10	3.98	0.12
Grade Guernsey..	22	21	27	46	53	5.20	4.67	0.53
Mixed	12	9	46	49	36	4.37	4.35	0.02
Total...........	166	179	247	392	438	4.92	4.59	0.33

It is thought that sufficient numbers of animals and tests are included in this compilation to make the results fairly conclusive, though the difference between summer and winter amounts to only .33 per cent. Apparently the test of Holstein cows is not affected by hot weather to so great an extent as that of Jerseys or Guernseys; in fact these data fail to show any appreciable difference between winter and summer tests of Holsteins.

SUMMARY

The feeding of prickly pear lowers the percentage of fat in the milk. The outstanding characteristics of prickly pear analyses are the high water and mineral contents.

The mineral matter is especially high in calcium and magnesium.

Much of the work reported above was done with the idea of finding what particular constituent was responsible for the decrease in percent of fat.

The quantity of water consumed does not affect the test.

Calcium either in the form of bone meal or limestone has no definite influence on the test.

A combination of high water and high mineral feeding as compared with low water and low mineral has no influence on the percentage of fat in the milk.

The carbonate and sulphate of magnesium do not lower the per cent of fat.

The feeding of 7 to 11 pounds per cow per day of cottonseed meal and linseed oil meal caused an increase in the fat content of the milk.

Gluten feed at the rate of 6 to 7½ pounds per day did not affect the test.

Linseed oil has the same effect as linseed oil meal.

Small quantities (2 or 3 pounds) of linseed oil meal do not seem to affect the test.

Apparently the influence of the linseed oil meal feeding on the percentage of fat in milk is temporary.

Since linseed oil exerts the same effect as the meal, and since gluten feed which is low in oil does not affect the test, the conclusion is that the results observed are due to the oil rather than the protein.

Exercise by walking three miles a day increases the test slightly but unmistakably.

Hot weather lowers the test.

The decrease is greater with those breeds yielding naturally a milk high in fat.

THE BACTERIAL CONTENT OF COW FECES*

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In estimating the importance of the different factors which have to do with the contamination of market milk, fecal contamination has sometimes been underestimated. In the past it has been assumed that 5,000,000 bacteria per gram is a fair average for the cow feces which contaminates milk. For fresh feces this average might stand. But it is the feces which has dried on the cows body at near blood heat which generally contaminates milk. When the bacterial content of this type of feces is determined it is found to contain about a billion bacteria per gram. It is easily seen that only a slight amount of contaminating material containing a billion bacteria per gram is needed to increase the bacterial content of milk tremendously. One-tenth of one gram per quart of milk might add half a million bacteria per cubic centimeter of milk.

The above facts were brought out pointedly by Dr. M. J. Prucha[1] in results read before the nineteenth annual meeting of the Society of American Bacteriologists.

It is the object of the work reported here to add further data to that already mentioned.

The media used was standard beef extract agar of reaction about pH = 6.8.

Two hundred and fifty representative colonies were taken from the plates of fresh feces and were placed in litmus milk tubes

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*Results obtained from Dairy Herds at University of Illinois and Cornell University.

[1] M. J. Prucha, H. M. Weeter, and W. H. Chambers, Germ life in cow feces, Abs. of Bacteriology, vol. ii, no. 1, p. 6 (1918).

TABLE 1

Bacteria per gram in fresh cow feces

FECES SAMPLES	PLATE COUNT, PER GRAM
1	43,000,000
2	1,000,000
3	30,000,000
4	39,00,000
5	634,000,000
6	26,000,000
7	320,000,000
8	500,000
9	160,000
10	2,640,000
11	21,200,000
12	230,000
13	44,000,000
14	37,000,000
15	378,000,000
16	510,000,000
17	14,000,000
18	20,000,000
19	44,000,000
20	7,000,000
21	14,000,000
22	630,000,000
23	390,000,000
24	53,100,000
25	1,820,000
26	570,000,000
27	5,000,000
28	191,000,000
29	624,000,000
30	1,320,000
31	6,900,000
32	24,600,000
33	27,500,000
34	405,000,000
35	3,300,000
36	78,200,000
37	9,800,000
38	14,000,000
39	11,670,000
40	17,500,000
41	5,860,000
42	265,000,000
43	26,500,000
44	5,940,000
45	525,000,000
46	30,000,000
47	12,760,000
48	23,000,000
49	6,500,000
50	41,600,000

TABLE 2

Bacteria per gram in cows' feces (dried)

Feces were dried on porous plate covers at 37° C. for forty-eight hours.

FECES SAMPLES	PLATE COUNT, PER GRAM
1	6,600,000,000
2	16,800,000,000
3	4,800,000,000
4	2,310,000,000
5	860,000,000
6	1,120,000,000
7	1,340,000,000
8	1,740,000,000
9	3,350,000,000
10	5,360,000,000
11	1,780,000,000
12	1,430,000,000
13	2,120,000,000
14	956,000,000
15	3,160,000,000
16	1,110,000,000
17	710,000,000
18	1,170,000,000
19	1,460,000,000
20	1,340,000,000
21	1,910,000,000
22	670,000,000
23	1,420,000,000
24	500,000,000
25	1,100,000,000
26	5,730,000,000
27	2,040,000,000
28	810,000,000
29	4,190,000,000
30	1,760,000,000
31	1,302,344,000
32	500,000,000
33	2,420,500,000
34	1,250,200,000
35	3,220,000,000
36	990,000,000
37	520,000,000
38	1,500,200,000
39	7,130,000,000
40	1,010,000,000
41	2,310,200,000
42	1,576,000,000
43	870,000,000
44	610,000,000
45	
46	920,000,000
47	1,809,000,000
48	9,130,000,000
49	3,410,000,000
50	810,000,000

which were incubated thirty days at 20°C. The results were as follows:

	per cent
Weak acid forming micrococcus	21.7
Strong acid and gas formers	8.4
Weak alkali forming rods	10.6
Strong liquefying rods (non-gas-forming)	18.7
Neutral micrococcus	12.4
Bacterium lactic acid	9.2
Aerogenes forms	8.4
Strong alkali forming rods	7.6
Fluoresens liquefaciens forms	2.0

It was found that when synthetic media varying between pH = 6.8 to pH = 7.3 were used and an incubation period of twenty days at 28°F., very much higher counts were obtained than are given in the foregoing table giving the bacterial content of cow's held for forty-eight hours. Due to this fact it is considered that flora results obtained from plates vary with the kind of media used. Due to this fact no flora determinations were made of the dried feces and those given for the fresh feces have little significance beyond showing what kind of organisms grow when standard beef extract agar is used.

CONCLUSION

We must revise our conception of how many bacteria one-tenth of a gram of dried cow's feces may add to market milk.

A SYSTEM OF REARING DAIRY CALVES WITH LIMITED USE OF MILK

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In 1907, experiments were begun here relative to methods of rearing calves under conditions where milk and its products were either unavailable or uneconomical to use. The results of studies made from 1907 to 1909 have been published by Savage and Tailby (1). The work described by these authors included studies of various proprietary calf meals and of dried milk products as substitutes for skim milk. In continuation of the work begun in 1907 the studies here reported describe results obtained with a system of feeding which does not involve the use of milk or its products after the first few weeks of age.

The need of such a system in dairy practice is for the dairyman who sells his product as market milk and has no skim milk for calf rearing; for the use of whole milk is too expensive to be practicable in most herds. The problem is by no means a new one. Both American and foreign literature are full of accounts of studies bearing on it. As a result of these studies many partial or complete substitutes for milk have been proposed and a large number of proprietary preparations are on the market. Some of them are enjoying a considerable use in practice, but there evidently still remains much to be desired from the standpoint of satisfactory growth and of freedom from digestive disturbances.

In an endeavor to overcome these limitations, an investigation of the problem has been in progress by the authors since 1919. It has involved experiments with laboratory animals and certain chemical studies of various feeding stuffs, as well as growth and metabolism studies with calves. The latter work has been confined largely to rations formulated at this station, although a few trials of proprietary calf meals have been made. In an endeavor to avoid as much as possible the digestive troubles frequently encountered in rearing calves, particularly where a substitute for milk is used, certain studies have been made of the relation of intestinal putrefaction and fermentation to these troubles. A preliminary report on this work has been published (2).

The present article deals only with growth studies with calves, made in 1921 and 1922. It seems desirable to publish this portion of the work apart from the rest because it indicates that substantial progress has been made and describes the results obtained with a system of feeding which, it is believed, is a contribution to animal husbandry practice. The present report must be considered a preliminary one, inasmuch as the work still in progress may modify somewhat the recommendations here tentatively suggested, as well as furnish further information on points not yet clear.

EXPERIMENTAL

In the studies reported in this paper, the milk normally received by the calf was replaced at about four weeks of age by a gruel made from the following combination of materials:

250 pounds	corn meal
250 pounds	red dog flour
150 pounds	ground oat groats
150 pounds	linseed oil meal
100 pounds	ground malted barley
100 pounds	soluble blood flour
10 pounds	precipitated calcium carbonate
10 pounds	precipitated bone meal
10 pounds	salt

The above formula, which may be referred to as a calf meal, was found to have the following analysis: water, 9.3 per cent; ash, 5.1 per cent; protein, 24.0 per cent; fiber, 3.5 per cent; N. F. E., 53.7 per cent; and fat, 4.4 per cent. The selection and proportion of ingredients is based on previous studies. The formula is especially designed to be as suitable as possible for the calf during the time when little other feed, such as hay and grain, is consumed. All of the ingredients are highly digestible and have been selected to make the mixture as low as possible in fiber. Each ingredient is finely ground, both because of presumably easier digestibility and because fineness of division is essential to avoid too rapid settling when the mixture is made into a gruel.

The blood flour furnishes a highly digestible animal protein to supplement the less efficient vegetable protein of the other ingredients. Blood flour has long been considered a valuable ingredient in calf meals both because of its nutrient value and because of a favorable effect in counteracting digestion troubles. The product used by us was entirely soluble in water and was obtained from the United Chemical and Organic Products Company, Chicago, Ill.

Linseed oil meal is another favorite ingredient of calf meals, not only because of its nutrient value but also because of its favorable physical effect. It also aids materially in keeping the meal in suspension in water due to its emulsifying properties.

Malted barley has a special value due to its diastatic action. That its addition results in a certain amount of saccharification of the higher carbohydrates of the other ingredients has been shown by our chemical studies.

It is obvious that a cereal grain mixture is deficient in lime as compared to milk. In earlier studies calcium carbonate alone was used. The combination of carbonate and phosphate was substituted at the suggestion of Dr. E. B. Forbes and we believe it has proved more satisfactory than the carbonate alone. The special sources of carbonate and phosphate used were chosen on the basis of purity, fineness of division and wholesomeness.

One can only speculate as to the suitability of the meal as regards vitamine content, since little is known as to the vitamine requirements of calves. The meal has resulted in normal growth in rats from four weeks of age to maturity. On the basis of the ingredients one would expect it to contain adequate B, to be rather deficient in A, and to be very deficient in C. However, it must be remembered that the calf probably stores some A during the period of whole milk feeding and that both A and C are supplied by roughage of the right character as soon as the calf begins to eat it.

The calves received hay and a dry grain mixture as soon as they would eat those feeds, following in this respect the procedure used with calves reared on milk. The dry grain ration was made up as follows:

30 pounds hominy
30 pounds ground oats
30 pounds wheat bran
10 pounds oil meal

The hay used was good quality clover or alfalfa.

The quality of the hay is especially important where a calf meal is used, because the more palatable it is the sooner the calves commence to eat it in quantity. This in turn develops the digestive tract, enabling it better to handle the substitute for milk. The great superiority of legume hay as regards lime and vitamines is a very important consideration in using it where milk is not fed.

THE CALVES

The animals used in the present trials comprised 7 grade Holsteins, 6 purebred Holsteins, and 2 purebred Shorthorns, all heifers. In all of our trials, with the exception of one of those reported here, the animals were limited, by reason of lack of barn space and other considerations, to those available in the University herd. For comparative purposes animals of the same breed and sex were desired and Holsteins were chosen because they were available in the largest numbers. In the last trial reported here, 2 Shorthorns were used, which represents the beginning of a plan, in so far as animals are available, to see how the calf meal will be handled by other breeds. The grade animals used were purchased from nearby farmers. They were healthy individuals, but not otherwise specially selected. Those calves from the University herd were not specially chosen; rather all available ones were used, except certain individuals deemed too valuable for use on experiment. At no time was any calf removed from the experiment by reason of lack of thrift or difficulty in handling the ration, it being recognized that ability to cause continuous normal growth was the primary measure of the value of the system of feeding.

FEEDING AND MANAGEMENT

The calves were kept in separate stalls and received the same general care accorded to similar animals in the University herd. Each calf was fed whole milk three times a day until the change was made to gruel. This change was usually begun during the fourth or fifth week, the exact time depending on the condition of the calf.

In keeping the calves on whole milk for about four weeks, it was recognized that the period is somewhat longer than holds in practice where skim milk is substituted for whole milk. In previous trials, we have started the substitution of gruel as early as two weeks of age and found it could be done satisfactorily with a fairly long period of change. However, we believe that feeding whole milk to about four weeks of age gives the animal enough better start, enabling a more rapid change to gruel with less digestive upset, to be worth while even though more whole milk is thus required.

About three weeks were allowed for making the change from milk to gruel. For calves over four weeks of age at the beginning of the change a shorter period usually sufficed. With all calves the period of change was governed by the condition of the calf rather than by any set rule. The beginning and duration of the period of change is shown for each calf in connection with figures 1, 2 and 4.

The gruel was made by mixing 1 pound of the calf meal with 5 pounds of water at about 100°F. It was fed three times a day. In changing from milk to gruel the first addition of the latter was that which would correspond to a daily ration of about ¼ pound of the calf meal. Beginning with this initial addendum, the gruel was gradually increased and the milk decreased until the change was completed. The milk and gruel were fed together. Assuming that a calf was receiving 12 pounds of whole milk before the period of change, the following illustrates a possible feeding schedule during the actual period:

DAY	WHOLE MILK	GRUEL
	pounds	*pounds*
1	9.0	1.5
5	7.5	3.0
8	6.0	4.5
11	4.5	6.0
14	3.0	7.5
17	1.5	9.0
20	0	9.0

It must be emphasized, however, that no set schedule was maintained with any calf. The length of the period of change, the times of increasing the addendum of meal and the actual amount of milk and gruel fed were all governed by the condition of the calf. If a given mixture of milk and gruel produced digestive disturbances, as shown by liquid or pasty and foul-smelling stools, no further change was made until these conditions disappeared. If they persisted for three or four days the food was usually cut down in amount, temporarily, or perhaps omitted entirely for a feeding. Sometimes in extreme cases, the proportion of milk to gruel was increased temporarily. This procedure was followed in recognition of the principles that it is not what the calf eats, but what it assimilates that is of benefit, and that it is better to underfeed the animal to the extent of a temporary retardation of growth rather than to cause digestion troubles which, if continuing for any considerable period, are difficult to overcome and result in slow growth over a protracted period. These principles apply to the calf reared on milk and they must apply with double force where a food much less suitable to the digestive system of the animal is being used. Detailed mention has been made of the feeding during the period of change because it is believed that the system of feeding according to the condition of the individual animal has been an important factor in the results obtained.

Having completed the change from milk to gruel, the latter was gradually increased with the appetite and condition of the calf. In general, no increase was made for at least a week after discontinuing the milk, thus keeping the gruel below what the calf might actually consume, in order to get it well started on the ration containing no milk. If the calf is carried through the period of change and for a week or so thereafter with only slight digestive upsets, the time of greatest possible trouble is over. The animal is accustomed to the change in food and is at an age when some hay and dry grain is being eaten and when its digestive system is becoming developed to handle the more bulky and less digestible feeds. For regular and maximum growth, however, the condition of the animal must be constantly watched to avoid overfeeding and digestive upsets, and the feed regulated accordingly. In general, the maximum daily feeding of gruel has been 15 pounds (2½ pounds calf meal) in these studies, usually fed during the fifth and sixth months. Many calves will eat more than this amount during this period, but it is more economical for them to get the rest of their nutriment out of dry grain and hay since they can handle the latter feeds in quantity at this time.

Hay and the dry grain were placed before the calves at three to four weeks of age. In general neither was consumed in any quantity until the seventh or eighth week. The rule followed in feeding hay and grain was to allow the calves all they would clean up. The grain mixture was fed twice daily in such amounts as would be cleaned up within an hour after feeding. The calves were watered twice daily.

With the idea of making up possible vitamine deficiencies a small addendum of carrots was made to the ration in the second trial reported in this paper. Carrots are rich in C and contain some A, the two vitamines most likely to be deficient under our system of feeding as has been pointed out. Bearing in mind that the period of most probable deficiency is during the time when little or no milk is being consumed and before the legume hay is eaten in any quantity, it was decided to begin the carrot feeding with the inauguration of the change from milk to meal. Since it was questionable whether calves four weeks old would handle raw carrots satisfactorily it was decided at the start to cook the carrots and to change to raw after the calf had gone through the transition period from milk to meal. It was recognized that cooking would destroy part of the vitamine C content, but it seemed better to accept such a loss than to add in raw carrots another possible factor contributing to digestion troubles during the period of change. The carrots were run through a food chopper, covered with boiling water and boiled for five minutes—a procedure designed to furnish the desired cooking with minimum loss of C. With the beginning of the change from milk to meal the cooked material, without any removal of water, was added to the milk—gruel mixture in an amount equivalent to $\frac{1}{10}$ pound of carrots per day. The addendum was gradually increased until at the time the milk was discontinued the calf was receiving $\frac{1}{2}$ pound of cooked carrots daily. At about this time, a change was made to chopped raw carrots, fed with the dry grain mixture. It was our practice not to begin with raw carrots until the calf was at least six weeks of age and eating $\frac{1}{2}$ pound of dry grain a day. The feeding of raw carrots was begun at $\frac{2}{10}$ pound per day and gradually increased to 1 pound per day, which was in general the maximum amount fed. The rate of increase depended on the grain consumption. The maximum addendum was not attempted until the calf was eating at least $1\frac{1}{2}$ pounds of dry grain daily. Some calves, of course, were much slower than others in reaching this figure. All the calves, with 1 exception, ate the carrots readily. No unfavorable results occurred from feeding them as far as could be observed.

THE MEASURE OF GROWTH

The ideal method of measuring the success attained with the system of feeding here described would be to compare the growth and development with that of a check lot reared on skim milk. Such a procedure was followed in an earlier trial, but was later given up because of lack of animals. With the publication by Eckles (3) of data as to the normal growth of dairy cattle, a very useful measure for our work became available. This investigator made a study of the growth from birth of the purebred dairy animals of the Missouri herd, recording the monthly increase in weight and height at withers, and thus was able to construct normal growth curves for the different breeds, based on a large number of individuals. Our results have been compared with these curves. As calves, the animals studied by Eckles were reared on skim milk together with grain and hay, usually alfalfa, from two weeks of age to six months, and were evidently subject to the same general conditions of management as obtain at the barns here. However, it is probable that our animals had an advantage as regards liberality of feeding, since they were given all the grain they would eat, while those reared at Missouri were evidently limited somewhat in this respect.

We were able to secure a few data from the University herd as to the growth of calves reared on skim milk when receiving all the grain they would clean up. The observations shown in table 1 were made during a period nearly corresponding to the one in which the second trial reported in this paper was carried out and embraced animals which were not included in the calf meal experiment, because of plans for their early disposal or other reasons.

TABLE 1

Average daily gain of purebred Holstein heifer calves reared on skim milk

CALF	WEIGHT AT BIRTH	WEIGHT AT SIX MONTHS	AVERAGE DAILY GAIN
	pounds	*pounds*	
E-9	95	421	1.81
213	100	411	1.73
221	99	408	1.72
222	96	396	1.66
223	88	390	1.68
225	91	391	1.67
Average........	95	402	1 71

The average daily gain shown in table 1 is 1.71 pounds in comparison to a figure of 1.44 pounds obtained from Eckles' data. Of course, as a fair mean, the figure of Eckles is more reliable because based on a much larger number of individuals, embracing animals born in every month of the year. Though more comparable as regards method of feeding, the data in table 1 are less useful than Eckles' for measuring the success attained in our trials because, due to lack of periodic weighings, no opportunity is afforded for comparing the regularity of the rate of growth, a measure especially desired with a system of feeding likely to cause temporary upsets. Thus Eckles' curves have been our principal basis of comparison. We have been careful, however, to point out, as will be noted in the discussion of the results which follows, the limitations involved. As a supplementary measure for comparison, the data in table 1 have been used.

The calves used in the studies here reported were weighed at birth, and weekly during the experimental period. The weighings were made at the same time of day so chosen as to be as long as possible after feeding or watering. To obtain the weight at the close of the six months experimental period, an average was taken of weighings on three successive days.

In the second trial, height at withers was measured at birth and monthly thereafter, taking an average of three measurements. Such measurements are subject to considerable error, but when plotted as was done by Eckles the trend of the curve indicates whether skeletal development is keeping pace with increase in weight.

In addition to increase in weight and height there are certain other measures of condition and development which are important in judging the success of a given ration, though they are difficult of quantitative expression. The experienced observer needs no scales or measuring stick to detect a thrifty animal. The character of the coat, the nature of the excreta, the shape of the belly and the activity of the animal all indicate how the feed is being handled. Careful observations were made from day to day of these less expressible measures of growth. They were used constantly in regulating the feed of the animals.

RESULTS

It is convenient to discuss separately the results obtained in the two trials reported since the experimental conditions were somewhat different. For this discussion the trials will be referred to as series A and B.

Series A

This trial was conducted in the summer and fall of 1921 using the 7 grade Holstein heifer calves previously mentioned.

The growth curves of these calves are shown in figure 1. It is noted that these curves do not start at the same point as the accompanying curve of normal growth. This is due to the fact that, being purchased calves, their birth weights were not known. However, their ages were known and the first point on the curve represents the weight at the age at which they were received at the University barn. The vertical dotted lines setting off the period of change from whole milk to gruel show that the change was usually begun somewhat later than at four weeks of age, as planned. This was due to the fact that most of the animals were three or four weeks old when received and the desirability of continuing the milk feeding until they became accustomed to their new surroundings, necessitated the delay. It is noted that growth was rather irregular, many instances of actual loss of weight being recorded. In several cases, these losses corresponded with periods of extremely hot weather and cannot be charged entirely to the nature of the ration. However, the curves show that most of the animals suffered at least a temporary check in rate of growth as soon as the milk was entirely removed, indicating that the system of feeding was not conducive to the regular normal growth desired. No check occurred with calves 12 and 16. For all of the calves, except calf 16, the period of

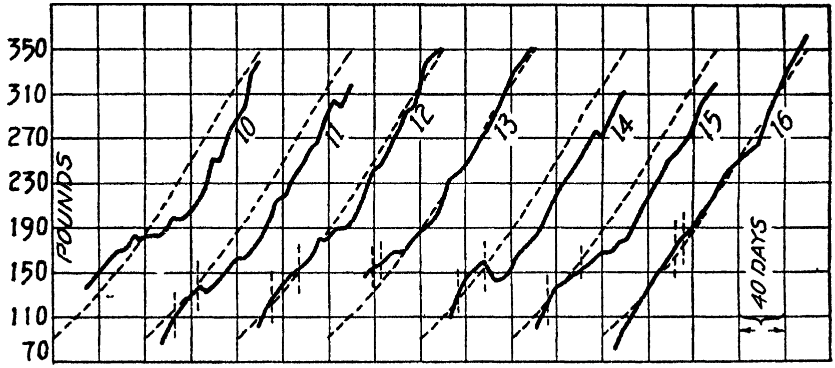

FIG. 1. CURVES OF GROWTH IN WEIGHT OF HOLSTEIN HEIFER CALVES (SERIES A)

The dotted curves represent normal growth according to Eckles' data.

The vertical dotted lines mark off the period during which the change was made from milk to gruel.

change and the subsequent four or five weeks coincided with the hottest months of summer. Thus, the results shown were obtained under the most adverse weather conditions. Further, each calf spent a day at three or four different times during the period following the change in a metabolism cage, which generally adversely affected appetite and disposition. Some metabolism studies were made with calf 16 while it was on milk, and this explains why the period of change was begun later for this calf. Thus the animal got a better start on milk than the others and this may account for the better and more uniform growth.

Though figure 1 shows the extent of success in securing continuous normal growth, the actual growth over the period is best indicated in table 2.

TABLE 2

Rate of growth of grade Holstein heifer calves (series A)

CALF	AVERAGE DAILY GROWTH
	pounds
10	1.34
11	1.40
12	1.55
13	1 40
14	1.31
15	1.40
16	1.67
Average	1 44

The average rate of growth of the animals on which Eckles' normal curve was based is 1.44 pounds per day. The data reported in table 2 show an identical average, a figure, however, that falls considerably short of the 1.71 pounds per day shown in table 1. The averages reported in table 2 do not cover the entire six months period since the rate of growth of the first two or three weeks could not be recorded. Omitting this period of slower growth would tend to make the figure reported larger than the true average for the full six months. The calves reported in table 2 were at a disadvantage with respect to those of Eckles in being grade animals, reared during the most unfavorable season and subject to the disturbances of the metabolism cage. On the other hand, they may have been fed more liberally. Though fed comparably to those reported in table 1 they were poorer individuals and were at a decided disadvantage as regards the time of year in which they were reared.

No serious digestive disturbances were caused by the gruel feeding. There were occasional instances of liquid or pasty and rather bad-smelling stools, but these difficulties always cleared up in a few days with a proper regulation of the food. The periods of retarded growth corresponded in general with those in which the food was cut down either due to lack of appetite or temporary digestion trouble. Where these periods were at all prolonged the coat became rough. In no case was pot belly markedly evident. At the close of the trial all animals were in good condition and their coats had practically lost any previous roughness.

Series B

The calves used in this series were purebred animals from the University herd, born from October, 1921, to March, 1922. They comprised 6 Holsteins and 2 Shorthorns. They were fed similarly to those in series A with the exception that all except the Shorthorn calf 133, received carrots fed as previously described. Calf 133 received no carrots, but was fed mangels, beginning with the tenth week. The growth curves for the Holstein calves are shown in figure 2. It is noted that all calves exceeded the check curve, 4 of them markedly. No retardation of growth is indicated following the omission of the milk. Over the entire six months the growth is seen to be regular, practically paralleling or exceeding the check curve at every period. It is believed that these results, showing regular normal growth free from digestion troubles even during the period of change and immediately thereafter, constitute the most important feature of the work here reported. A more regular growth than occurred in series A would be expected because of the more favorable weather conditions, better individuals, and absence of experimental disturbances. Nevertheless it is felt that the addition of

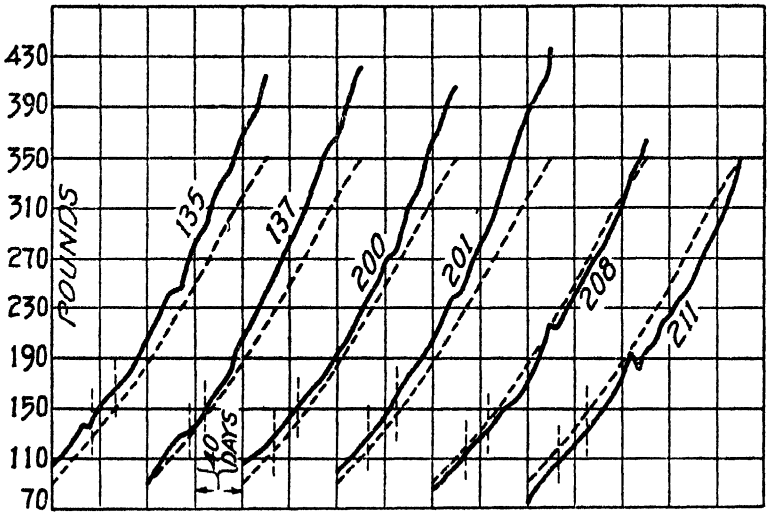

FIG. 2. CURVES OF GROWTH IN WEIGHT OF HOLSTEIN HEIFER CALVES (SERIES B)

The dotted curves represent normal growth according to Eckles' data.

The vertical dotted lines mark off the period during which the change was made from milk to gruel.

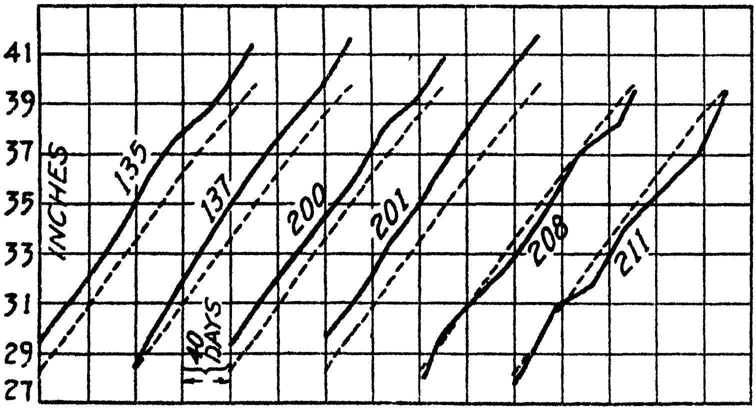

FIG. 3. CURVES OF GROWTH IN HEIGHT AT WITHERS OF HOLSTEIN HEIFER CALVES (SERIES B)

The dotted curves represent normal growth according to Eckles' data.

The abscissas mark off periods of forty days.

carrots to the ration must have also been a factor. A comparison of the results with some obtained the previous winter, where no carrots were fed, indicates that the carrots must have had a favorable effect on growth.

That the growth as shown by increase in weight was accompanied by a corresponding skeletal development is shown in figure 3. The curves for increase in height at withers are seen to equal or exceed the check, even as occurred in the case of the weight measurements.

The extent of the growth obtained is best shown in table 3.

TABLE 3

Rate of growth of purebred Holstein heifer calves (series B)

CALF	WEIGHT AT BIRTH	WEIGHT AT SIX MONTHS	AVERAGE DAILY GAIN
	pounds	*pounds*	*pounds*
135	105	416	1.73
137	90	423	1 85
200	107	408	1.67
201	99	438	1 88
208	88	365	1.54
211	77	350	1.52
Average....... .	94	400	1 70

In making an average daily gain of 1.70 pounds per day the group of calves reported in table 3 equaled the average gain made by the six similar animals reported in table 1 which were reared on skim milk in a nearly identical period. Thus, it would appear that under our system of feeding results were secured comparable in both rate and regularity of growth to those obtained with calves reared on skim milk.

As would be indicated from the regularity of the growth, the calves in series B experienced little digestion trouble, being more free from it than those in series A. It is believed that there was little if any more occurrence of abnormal feces and of going-off feed than occurred with the group reared on skim milk.

The results obtained with the Shorthorn calves are shown in figures 4 and 5. Eckles' data as to the increase in height of

Shorthorns begin at thirty days instead of at birth, which explains the starting point of the dotted curve in figure 4. Both the calves are seen to have exceeded the average. It is not worth while to discuss the results with only 2 individuals of a breed except to point out that the results support those obtained with the Holsteins.

In reporting the work described in series A and B, it has been our primary object to show that calves can, by a proper system of feeding, be reared satisfactorily without milk after four to eight weeks of age, and that gains comparable to those produced by skim milk are possible. The work leaves many questions, some of great practical interest, unanswered. No mention has been made of the amount of food consumed and the cost thereof. Though we have feed records for the work reported, these records are not as accurate as desired, and it seemed best to postpone the report on feed consumption and cost until there is completed the studies now in progress especially planned to overcome the difficulties of securing accurate data on these points.

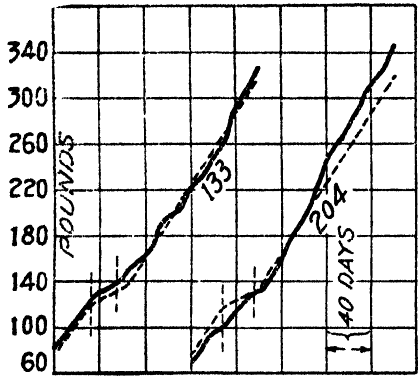

FIG. 4. CURVES OF GROWTH IN WEIGHT OF SHORTHORN HEIFER CALVES (SERIES B)

The dotted curves represent normal growth according to Eckles' data.

The vertical dotted lines mark off the period during which the change was made from milk to gruel.

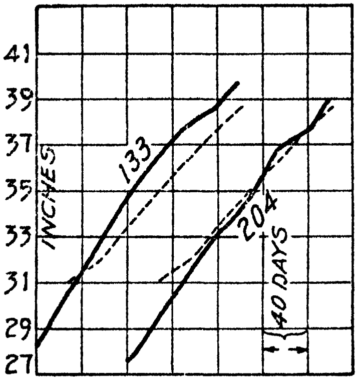

FIG. 5. CURVES OF GROWTH IN HEIGHT AT WITHERS OF SHORTHORN HEIFER CALVES (SERIES B)

The dotted curves represent normal growth according to Eckles' data (curves begin at age thirty days).

That the carrots were in part responsible for the excellent results in series B is probable but not proved. By the use of a check lot not receiving carrots it is hoped to clear up this point in the studies now in progress. Our results showed that the addition of carrots stimulated the consumption of dry grain. The question arises as to whether the effect of the carrots lay solely in causing the calf to eat more food or whether they constituted an otherwise useful constituent of the ration, perhaps furnishing a needed vitamine. It is hoped that the work now in progress will furnish some answer to these questions.

Just what contribution to the success of the results is made by beginning the carrot feeding as early as was done, and whether cooking is necessary at this stage, are points which must be made clear because of the questionable practicability of the procedure. The question further arises as to whether other roots, such as mangels, would be as satisfactory as the carrots.

The system of feeding here described is by no means recommended to replace the use of skim milk. Where the latter is available, it constitutes the more economical and presumably the more satisfactory method. In its absence, the results obtained with the system of feeding described are believed such as to commend it as a useful alternative.

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STUDIES IN THE GROWTH AND NUTRITION OF DAIRY CALVES

VII. THE USE OF THE SELF-FEEDER WITH YOUNG DAIRY CALVES

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Appetite, as an indicator of physiological needs, has been minimized by many investigators in the field of human and animal nutrition. From the beginning the whole animal kingdom has been controlled in its feeding problems only by appetite and environmental limitations of the feed supply. Consequently, even though the rôle of appetite be not of great importance under artificial experimental conditions, yet, if the broad facts of the case, the continued existence and multiplication of man and other animals after countless eons of feeding with appetite as their sole guide, be taken into consideration, it must be recognized as of some value.

RÉSUMÉ OF PREVIOUS WORK

The attention that has been given to the study of appetite can hardly be called critical. Evvard (54) has reviewed the literature on the subject and shown that appetite is a fairly reliable indicator of the physiological needs of the pig. A very limited amount of work has been done with cattle, but other material, not obtained with a view to studying the appetite of animals, may be reviewed here as of interest in connection with the work reported on the grinding of grain for calves.

It has been stated by Jordan (56) that the grinding of oats and corn increased their digestibility in the case of horses, though with sheep whole oats were as completely utilized as ground grain.

It has been found by Fain and Jarnagin (55) that, where corn meal and shelled corn were used to supplement skim milk for calves, the daily consumption of shelled corn was greater than that of corn meal, though the rate of gain was greater and the amount of grain consumed per 100 pounds live weight gain less in the case of the shelled corn. Kildee (57) also recommended whole oats in preference to ground oats for calves. Otis (58) found that calves fed shelled corn made larger gains and consumed less skim milk and hay, but slightly more grain per 100 pounds live weight gain, than did those fed corn chop. He also found that skim milk calves, two to three months old, consumed about 10 pounds of water per head daily.

TABLE 56

Animals used

	CALF 411	CALF 413	CALF 414
Breed	Guernsey	Ayrshire	Holstein
Sex	Male	Female	Female
Initial age, days	70	37	30
Initial weight, pounds	146	110	110

In view of the work that has been done with the self-feeder as an adjunct in the management of other types of live stock this work was undertaken with young calves. The main object was to determine the ability of calves to select rations suited to their needs, to see their preferences for the various concentrates and obtain some knowledge of their demands for salt water.

EXPERIMENTAL WORK

Three calves, 2 heifers and a bull were used. All were in good growthy condition and information concerning them is given in table 56.

From the time they were taken from their dams at about three days of age, until the beginning of the experiment, the calves had been fed whole milk. All had become accustomed to consuming small quantities of hay, while the bull, no. 411, was the only one familiar with grain.

The experiment lasted for two periods of thirty days each, and throughout this time the animals were given what milk was thought to be suited to their needs, skim milk being used to replace part of the whole milk as they became older. A supply of alfalfa hay, of medium quality, was kept before the animals at all times. A self-feeder in the pen contained the following feeds in separate compartments:

Shelled corn
Cracked corn
Whole oats
Ground oats
Hominy feed
Linseed oil meal (O.P.)
Wheat bran
Corn gluten feed
Salt
Charcoal

For a few hours each day fresh water was kept in front of the calves.

TABLE 57

Individual milk consumption (arbitrarily allowed)

	PERIOD I			PERIOD II		
	Calf 411	Calf 413	Calf 414	Calf 411	Calf 413	Calf 414
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
Whole milk	276	294	294	226	226	226
Skim milk	84	42	42	226	226	226
Total milk	360	336	336	452	452	452

At the beginning of the experiment and at the end of each thirty-day period the animals were weighed on each of three consecutive days. The average of the three consecutive weighings was taken as the live weight of the animals.

A daily record was kept of the amounts of milk, hay and water consumed and records of the other feeds used were obtained for each thirty-day period. Moisture determinations were made on all feeds to allow of the computation of the total water and dry matter consumption.

DISCUSSION OF RESULTS

Milk consumption records were obtained for each animal and in table 57 are given by thirty-day periods. In period I the bull was given more milk than the heifers, but during period II each animal received 226 pounds of whole milk with an equal quantity of skim milk.

The total consumption for the group, of whole and skim milk, the various concentrates, hay, salt, charcoal and water are collected in table 58.

TABLE 58

Total feed consumption

	PERIOD I	PERIOD II
	pounds	*pounds*
Milk:		
Whole	864.0	678.0
Skim	168.0	678.0
Concentrates:		
Shelled corn	1.3	108.6
Cracked corn	0.0	0.3
Whole oats	58.7	68.4
Ground oats	0.4	0.5
Hominy feed	0.0	0.3
Gluten feed	15.3	1.9
Wheat bran	13.3	17.3
Oil meal (O.P.)	62.7	75.6
Alfalfa hay	32.7	91.9
Salt	1.1	0.3
Charcoal	0.7	1.3
Water	384.0	689.0

The relative consumption of whole and ground grains can be more clearly appreciated when they are considered separately.

From this evidence one fact is very apparent—the calves showed a decided preference for the whole rather than the ground grains. During period I practically no corn was consumed but in period II there were 108.6 pounds of whole corn and only 0.3 of a pound of cracked corn taken. The whole oats was consumed to the extent of 58.7 pounds in the first period and 68.4 pounds in the second period while never more than 0.5 of a pound of ground oats was consumed in thirty days. Hominy feed was also neglected in favor of the whole corn and oats. The total consumption of whole grain was 237 pounds while that of ground grain was 1.5 pounds.

Oil meal was the most favored of the nitrogenous concentrates, and the consumption of it increased as the experiment progressed. Wheat bran was a poor second while gluten feed appeared to be the least desirable, as only 1.9 pounds of it were consumed during period II as compared with a consumption of 15.3 pounds in period I. This decided decrease in consumption of gluten feed may perhaps be linked up with the increase in consumption of shelled corn, which in turn was probably due to another factor, the skim milk increase in the ration.

As the experiment progressed the daily allowance of skim milk was increased at the expense of the whole milk. This tended to narrow the nutritive ratio of the ration. The calves counteracted this, however, by increasing their consumption of low protein concentrates from 60.4 pounds in period I to 178.1 pounds in period II, or 195 per cent, while the increase in their consumption of high protein concentrates was relatively small, going from 91.3 pounds in period I to 94.8 pounds in period II, or only 4 per cent.

The consumption of alfalfa hay, water and charcoal increased as the experiment progressed, while that of salt decreased.

From this it is apparent that the consumption of grain, hay and water increased very rapidly with the growth of the calves, the average daily requirements of water mounting from 4.27 pounds in period I to 7.66 pounds in period II.

This again demonstrates the rapid increase in dry matter consumption from 290.9 pounds in period I to 463.2 pounds in period II, while the total consumption of water, as drinking water and in the feed, increased from 1311.3 pounds to 1948.2 pounds, or from 14.57 pounds per day in period I to 21.65 pounds per day in period II.

The live weight gains were very creditable, varying from 1.60 pounds to 2.30 pounds and averaging 1.98 pounds per head per day. The calves did not become too fat but remained in good growthy condition—that most desirable for young dairy calves.

TABLE 59

Consumption of whole and ground grains

	PERIOD I	PERIOD II	TOTAL
	pounds	*pounds*	*pounds*
Whole grain:			
Corn	1.3	108.6	
Oats	58.7	68.4	237.0
Ground grain:			
Corn	0.0	0.3	
Oats	0.4	0.5	
Hominy	0.3	0.0	1.5

TABLE 60

Average daily feed per calf

	PERIOD I	PERIOD II
	pounds	*pounds*
Whole milk	9.60	7.53
Skim milk	1.87	7.53
Concentrates	1.69	3.03
Hay	0.36	1.02
Salt	0.012	0.003
Charcoal	0.008	0.013
Water	4.27	7.66

TABLE 61

Consumption of dry matter and water

	CONSTITUENT			
	Dry matter		Water	
	Period I	Period II	Period I	Period II
	pounds	*pounds*	*pounds*	*pounds*
Milk	127.8	153.3	904.2	1,202.7
Concentrates	133.6	230.4	18.1	42.5
Hay	27.7	77.9	5.0	14.0
Condiments	1.8	1.6		
Water			384.0	689.0
Total	290.9	463.2	1,311.3	1,948.2

TABLE 62

Live weight gains

	CALF 411	CALF 413	CALF 414	TOTAL	AVERAGE
	pounds	*pounds*	*pounds*	*pounds*	*pounds*
Live weights:					
Initial	146	110	110	366	122
Middle	209	158	164	530	177
Final	278	219	226	723	241
Live weight gains:					
Period I	63	48	54	165	55
Period II	69	61	62	192	64
Total	132	109	116	357	119
Average daily gains:					
Period I	2.10	1.60	1.80	5.50	1.83
Period II	2.30	2.03	2.07	6.40	2.13
Average	2.20	1.82	1.93	5.95	1.98

TABLE 63

Feed required for 100 pounds live weight gain

	PERIOD I	PERIOD II
	pounds	*pounds*
Whole milk	524	353
Skim milk	102	353
Grain	92	142
Hay	20	48
Water, drinking	233	359
Total dry matter	176	241
Total water	795	1,015

TABLE 64

Actual and expected consumption of nutrients by calves

	PERIOD I		PERIOD II	
	Actual nutrients	Expected nutrients	Actual nutrients	Expected nutrients
Total dry matter, pounds	209.9	267.9	463.2	412.8
Digestible crude protein, pounds	66.4	43.8	94.1	60.9
Total digestible nutrients, pounds	292.8	230.1	425.1	327.9
Nutritive ratio	1:3.4	1:4.3	1:3.5	1:4.4

The feed requirements per 100 pounds of live weight gain are relatively low.

The calves showed distinct preferences for some of the grain preparation, but there is the question, how near did they come to balancing their rations in accordance with the concepts of modern feeding standards?

The consumption of dry matter and digestible nutrients by the calves is seen to be well above expectations but it has already been shown that the heavy feed consumption led to large and economical gains. According to the Modified Wolff-Lehmann Feeding Standard the feed for the calves should on the average have had a nutritive ratio of 1:4.3 in the first period and 1:4.4 in the second. However, the calves seemed to prefer a ration with a much narrower nutritive ratio. For the first and second periods the nutritive ratios of the rations were 1:3.4 and 1:3.5, respectively. In this choice of a narrower nutritive ratio the calves may have been correct. The calves grew rapidly and gained in weight but did not become too fat and this is the desirable method of growing out young dairy animals.

SUMMARY

This work is too limited in scope to allow of the making of definite recommendations but a few points of interest stand out clearly:

1. Young calves prefer whole corn and oats to the ground grains.
2. Hominy feed does not appear to be palatable to calves.
3. Linseed oil meal (O.P.) appears to be more palatable than wheat bran, while corn gluten feed is not in favor with calves.
4. Calves have the ability to vary their consumption of concentrates to comply with their needs. For example, when whole milk is replaced by skim milk the calves increase their relative consumption of low protein concentrate feeds such as corn and oats.
5. The calves used in this work consumed a ration of much narrower nutritive ratio than is generally recommended.

6. The calves maintained the nutritive ratio of their ration fairly constant though it became slightly wider as the calves advanced in age.

7. The consumption of hay increased materially as the calves became older.

8. Salt and charcoal were evidently desired by the calves.

9. Water is important, even for calves fed milk.

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A TEST FOR DETERMINING THE CHARACTER OF THE CURD FROM COWS' MILK AND ITS APPLICATION TO THE STUDY OF CURD VARIANCE AS AN INDEX TO THE FOOD VALUE OF MILK FOR INFANTS[1]

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INTRODUCTION

Great difficulty has been experienced in adapting cows' milk to the needs of very young infants and also in its use by older infants at weaning time. Usually the transition period from mothers' to cows' milk is accompanied by little or no gain in weight by the child and often results in a loss.

Some of the more delicate infants die as a result of the lack of a food that they can properly digest and assimilate. Considerable difficulty is experienced by most infants in digesting the curd of cows' milk which has a comparatively tough, hard texture differing from the fine feathery appearance of mothers' milk. To so modify the milk as to render the curd more digestible by infants is one of the big problems of infant feeding. Most babies will make good gains on a milk that can be properly digested irrespective of the animal from which it is obtained.

Physicians often recommend mixed herd milk in preference to individual cows' milk. This is usually a wise recommendation, but if the milk from some of the cows is shown to be more digestible than that of the rest of the herd it would be desirable to use this milk in preference to mixed herd milk.

Often various milks and milk substitutes are experimented with until finally a milk or other substitute is found upon which the infant makes gain. One purpose of this test is to determine, if possible, in advance the adaptability of the milk for the infant as well as in aiding in the elimination from the special baby milks of the milk shown to be hard-curded. The results to date have been very encouraging. Infants have made constant and consistent gains on the milk shown to be soft-curded by the test even immediately after weaning. In some cases a change from the soft-curded to the mixed herd milk has completely upset the infant which was soon restored to normal by a return to the soft-curded milk. The data collected to date are insufficient to warrant any positive statement as to the practical value of the test. However, the feeding of the soft-curded milk has given very favorable results.

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[1] Studies on the curd test were begun by the author while at the Maryland Agricultural Experiment Station where considerable data were obtained by the use of the test in its original form. The test in its present form and all results used in this publication were developed at the Utah Agricultural Experiment Station.

DETAILS OF THE MANIPULATION OF THE TEST

The curd knife. For determining the hardness of the curd a star-shaped, 10-pronged curd knife is used. This knife has a $\frac{3}{8}$-inch center which is tapered at 60° to fit over a $\frac{1}{8}$-inch stem. The stem is used as the handle and is $6\frac{1}{4}$-inches long before it is bent to form the $\frac{1}{4}$-inch loop in the end. Into the ten $\frac{1}{8}$- by $\frac{1}{20}$-inch slits in the center the ten blades are soldered. The blades are cut from $\frac{1}{20}$-inch sheet brass and are $\frac{1}{8}$-inch wide and all are sharpened to a knife edge. Each blade is cut twice the length needed for the knife blade. It is then placed in a bending jig and bent at an angle of 36°. Five blades thus bent are soldered into the center core to furnish the ten blades. The knives when completed weigh on the average 17.5 grams and should not vary in weight more than 0.5 gram (see fig. 1).

The spring balance. For measuring the tension required to draw the curd knife through the curd a specially constructed spring balance with a capacity of 200 grams and a sensitivity of 0.5 gram is used. This balance was manufactured for the experiment by John Cataillon and Sons of New York.

The coagulation cylinders. The 8-ounce screw-capped jars manufactured by the Whitall Tatum Company are used for containers for the milk to be tested. The jars should be examined for uniformity before use.

The coagulant. For coagulating the milk a pepsin-calcium-chloride mixture is used. Marked differences can be obtained by the use of pepsin alone. The use of calcium chloride, however, increases the variation and decreases the coagulation time and gives a more uniform coagulation. The coagulant consists of a mixture of three parts of a 0.6 per cent solution of Eimer and Amend's 1 to 3000 scale pepsin to 1 part of a saturated solution of calcium chloride.

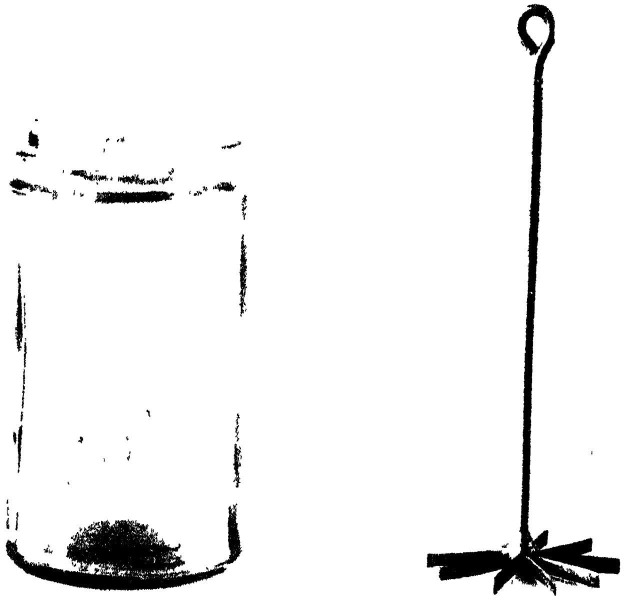

FIG. 1. THE CURD KNIFE

METHOD OF PROCEDURE

The milk should be tested as soon as possible after it is drawn from the cow, as a marked increase in acidity will alter the test. When comparative results are to be obtained it should be held at a constant temperature and tested the same length of time after milking. Duplicate 100 cc. samples of thoroughly mixed milk are placed in the glass jars previously described. The jars are then immersed in a water bath and the temperature of the milk brought up to 35°C. They should be maintained at this temperature throughout the test. After placing the curd knives in the jars, 10 cc. of freshly mixed coagulant are added by means of a very rapidly flowing pipette. It is sometimes necessary to enlarge the opening in the pipette to allow a more rapid flow. The jar should be agitated to give the milk a circular motion while the coagulant is being added, thus assuring a more even mixture of the coagulant. The amount and uni-

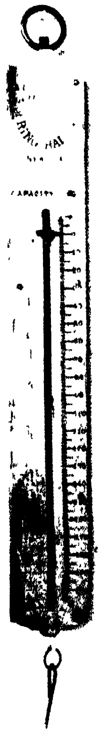

Fig 2. The Spring Balance

formity of the agitation given the jars during the addition of the coagulant is very important. Too rapid or prolonged agitation will agglutinate the curd, while little or no agitation will not adequately mix the coagulant with the milk resulting in an uneven coagulation. The author adds the coagulant with a pipette held in the left hand while the jar is agitated with the right. By a little practice a uniform and smooth motion can be obtained.

After adding the coagulant the jar should be returned to the water-bath, care being taken not to agitate the same for a period of ten minutes when the spring balance is hooked through the loop in the curd knife and by a slow and even tension the knife is drawn through the curd. The amount of tension required can be read directly on the balance. Deducting the weight of the curd knife will give the net tension required. It is very essential that the spring balance be held directly above the curd knife with a perpendicular slope; otherwise, friction of the plunger on the sides or back of the scales will render the test inaccurate.

By using a large number of knives one can run duplicate samples on from 15 to 20 cows at one time. If it is used immediately, coagulant for 40 or more samples can be mixed before starting. The pepsin deteriorates, however, if violently agitated or if it is allowed to stand too long in the calcium-chloride solution.

When one becomes experienced with the method duplicate samples will check under his manipulation to within about 5 grams. Some may vary as much as 10 grams, while most samples check almost exactly. The variation between the hard- and soft-curded milks is so great as to overcome slight variations in samples.

NORMAL VARIATION IN THE CURD CHARACTER OF COWS' MILK

The normal variation in the curd character of the milk from the cows of the Utah Agricultural College dairy herd is shown for a period of six months by curves in figures 3 and 4. Figure

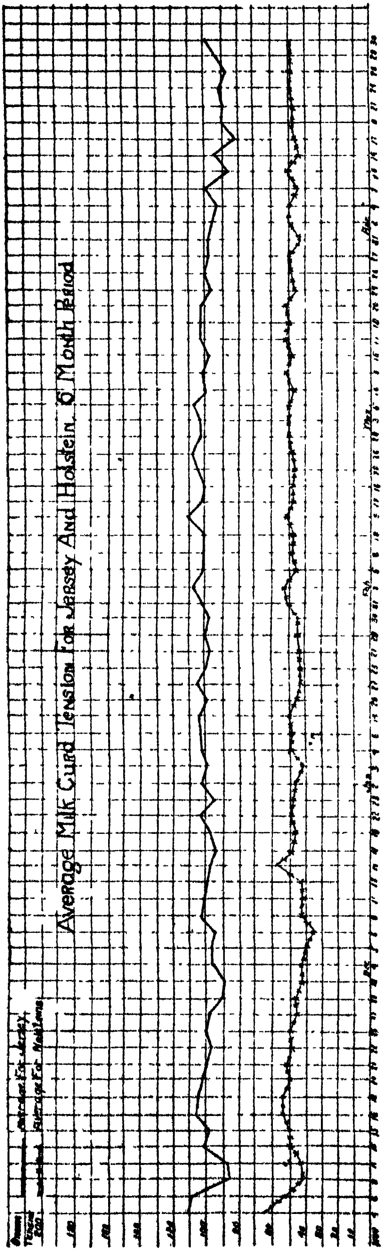

FIG. 3. CURVE SHOWING GRAMS OF MILK CURD TENSION OF JERSEY AND HOLSTEIN AVERAGES FOR THE ENTIRE HERD OF 25 COWS OF THE UTAH AGRICULTURAL COLLEGE DAIRY HERD FOR A SIX-MONTH PERIOD

Perpendicular figures indicate grams of milk curd tension. Horizontal figures indicate date on which test was made.

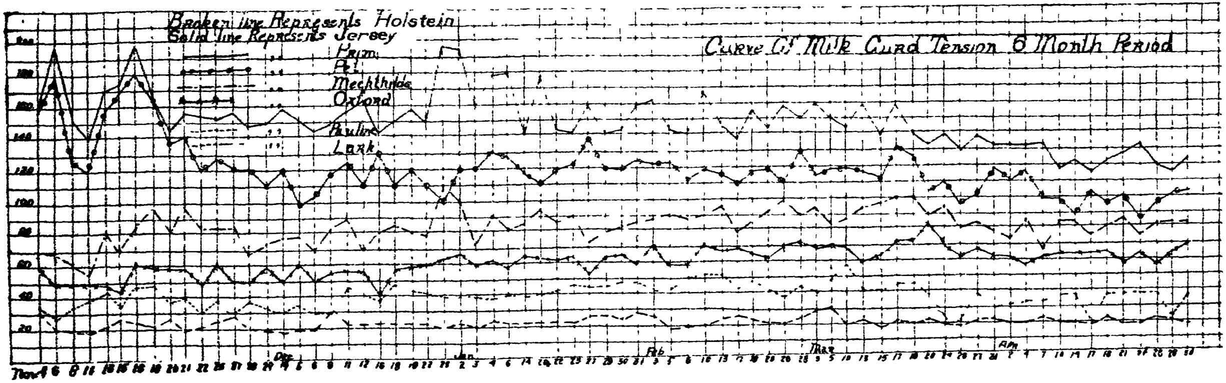

FIG. 4. CURVE SHOWING GRAMS OF MILK CURD TENSION OF SIX TYPICAL COWS FROM THE UTAH AGRICULTURAL COLLEGE DAIRY HERD FOR A SIX-MONTH PERIOD

Perpendicular figures indicate grams of milk curd tension. Horizontal figures indicate date on which test was made.

3 shows the average test of all the Jerseys and all the Holsteins for a six-month period, while figure 4 gives the curd test on 6 typical cows for the entire period. To obtain these curves the samples of the entire herd were run at one time under as nearly identical conditions as could be obtained. The samples were taken personally by the laboratory assistant who placed them in cold water as soon as taken. They were held at about 15°C. until they were warmed for coagulation. In spite of these precautions there appears considerable variation in the curd character from day to day, as can be seen from the curve shown in figure 4.

It was observed that the first milk received from the cow after the colostrum period is over was almost invariably harder than the milk obtained a few weeks later. Taking the entire lactation period there was a marked uniformity in the curd character. This is well shown by the curve in figure 3.

EFFECT OF BREED ON THE CURD CHARACTER OF THE MILK

The only two breeds of dairy cows considered in this paper are the Jersey and Holstein. Work was done while the author was at the Maryland Agricultural Experiment Station on the Guernsey and Ayrshire breeds, but these results were before the test was in its present form and therefore not included in this report.

As a general rule the Jersey breed appears to have a much harder curd than the Holstein. The amount of tension required to cut the curd in some instances is 10 times as great in the Jersey as with the Holstein milk.

There is, however, a considerable individual variance within the breed and the milk of some Holsteins is invariably harder than the milk obtained from some of softer Jerseys. The average for the Holstein cows, however, was considerably lower than the average for the Jerseys.

The curve in figure 3, showing the average hardness of the Jersey and Holstein milk, is for a period of six months and indicates the almost uniform difference between the curd character of the two milks. The curve in figure 4 shows the curd variance

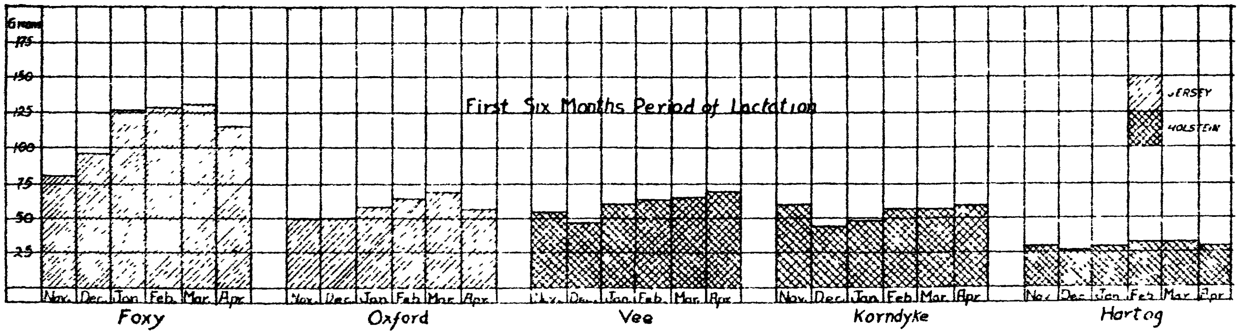

FIG. 5. GRAPH SHOWING EFFECT OF PERIOD OF LACTATION ON THE MILK CURD TENSION USING TYPICAL COWS FROM THE UTAH AGRICULTURAL COLLEGE DAIRY HERD IN THE FIRST SIX-MONTH PERIOD OF LACTATION

of some selected cows from the Holsteins and Jerseys. From this curve it can be seen that the milk of Mechtilda, a Holstein, was invariably harder for the entire six-month period than that of Oxford, a Jersey. By referring to the graphs shown in figures

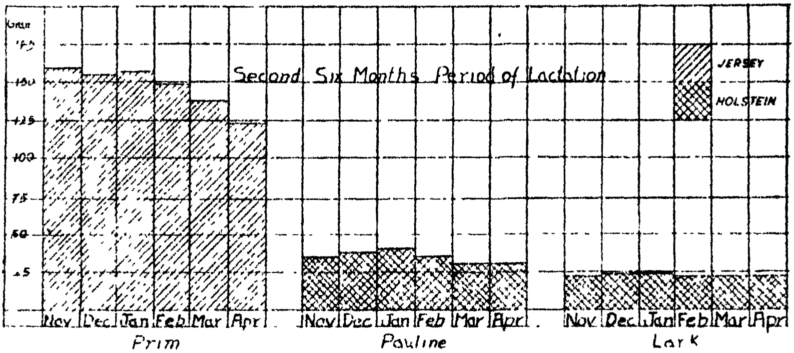

FIG. 6. GRAPH OF THE MILK CURD TENSION OF COWS IN THE SECOND SIX-MONTH PERIOD OF LACTATION

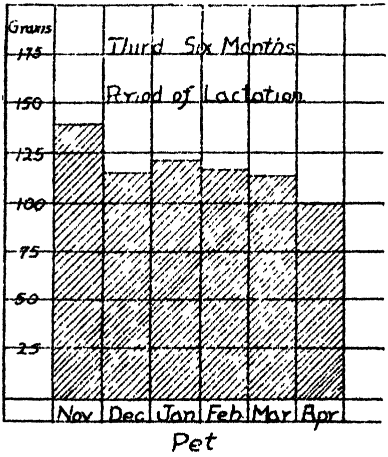

FIG. 7

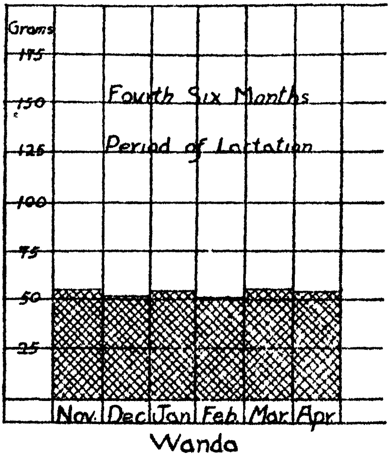

FIG. 8

FIG. 7. GRAPH OF MILK CURD TENSION OF COW IN THE THIRD SIX-MONTH PERIOD OF LACTATION

Note the gradual decrease in tension.

FIG. 8. GRAPH OF THE MILK CURD TENSION OF A HOLSTEIN COW IN THE FOURTH SIX-MONTH PERIOD OF LACTATION

5, 6, 7, and 8 the curd variance for this six-month period is graphically indicated. From these, the extreme variance in curd texture between Lark, the softest Holstein, and Prim, the hardest Jersey, can be seen as well as the greater variability in milks of the harder curded cows.

THE PERIOD OF LACTATION AS AFFECTING THE CURD CHARACTER OF THE MILK

At the present writing the author is unable to supply results of the curd character for an entire lactation period on the same cow. Beginning with October 1922 the Utah Agricultural College dairy herd was classified according to the lactation period of the cow. Some cows had just freshened, while others had been lactating six, twelve, and eighteen months. The curd variance of the milk of cows in the first, second, third, and fourth six-month period of lactation all taken during the same period is shown by these graphs in which a slight increase in hardness of the curd is apparent. This increase was neither uniform nor universal. The milk of Hartog, one of the softest curded Holsteins, decreased in hardness for this period, while that of Foxy, a Jersey, showed a large but uneven increase.

For the second six-month period graphs of but 3 cows are shown. Of these, Prim, the hardest curded Jersey, decreased in milk curd tension about 27 per cent. This decrease was not uniform, yet it exhibits a greater degree of uniformity than most of the graphs. Pauline and Lark, the other 2 cows in this period, are two of the softest curded Holsteins and their milk is used as special baby milk. During the six-month period Pauline showed slight decreases and increases in the curd tension of her milk, while the milk of Lark remained remarkably constant and uniformly soft for the entire period.

Only 1 Jersey was in her third six-month period of lactation, having calved a year prior to the commencing of the experiment. This cow, Pet, shows an irregular but decided decrease in milk curd tension for the period. At the beginning of the experiment 1 cow, Wanda, a Holstein, had been milked eighteen months. Her remarkably uniform record is shown in the graph of figure 8.

Summarizing these results, there seems to be a tendency for a cow to increase in curd tension of her milk for the first half of a normal lactation period and then gradually decrease for the remainder of the period. This is not a uniform rule. Any udder inflammation or infection has a tendency to harden the curd of the milk. A decided change in curd tension was also observed when the cows were "in heat", which in part explains some of the irregularities in the curve of their milk tension.

INFLUENCE OF THE FAT CONTENT UPON THE CURD CHARACTER OF THE MILK

The fact that the average curd tension of the Jerseys was higher than that of the Holsteins may lead some to conclude that the fat content was a limiting factor in curd tension. Our results, however, show that the curd tension is independent and apparently in no way related to the fat content of the milk. To test this still further large samples of the milk from 12 cows —6 Jerseys and 6 Holsteins—were taken. A small sample was set aside and run for curd tension according to the usual method. The rest of the milk from each cow was separated separately in a very small Viking separator. The separator was washed between each sample and the first milk separated from each sample discarded. The curd test was then made on the skimmed milk of each cow. The results of these tests are shown in table 1 and the graphs of figures 9, 10, and 11.

From the table and graphs it is evident that the curd tension was increased by the removal of the fat from the milk and also that there was no direct correlation between the fat content of the milk and the curd tension. By comparing figures 10 and 11 the remarkable uniformity in the results of April 10 and 21 can be seen. In general, the larger the fat content the greater the increase in the curd tension as a result of its removal, its presence serving to soften the curd of the milk. This may account for the fact that sometimes infants that cannot digest the mixed milk do well on "top milk".

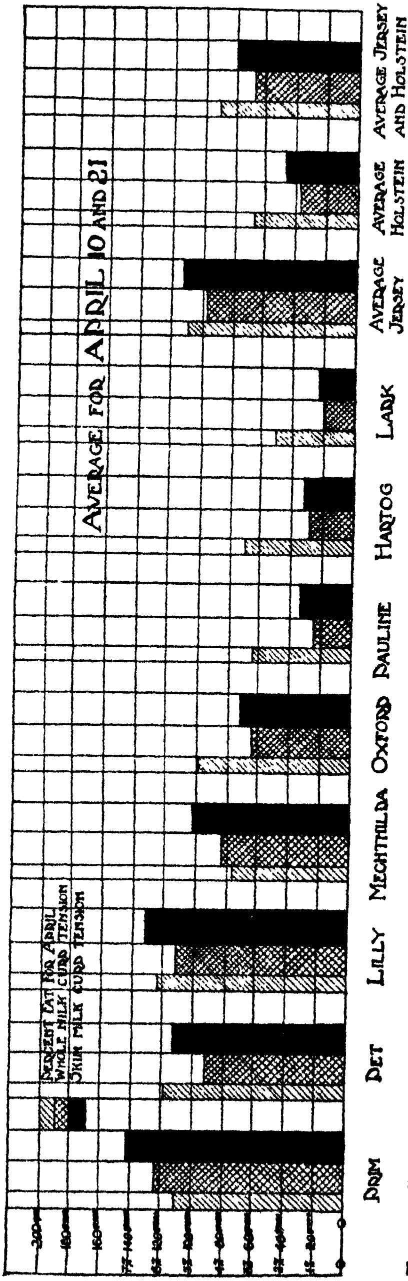

Fig. 9. Graph of Average Milk Curd Tension Before and After Removal of the Fat of Jersey and Holstein Cows

Note the uniformity in graph, figures 9, 10, and 11

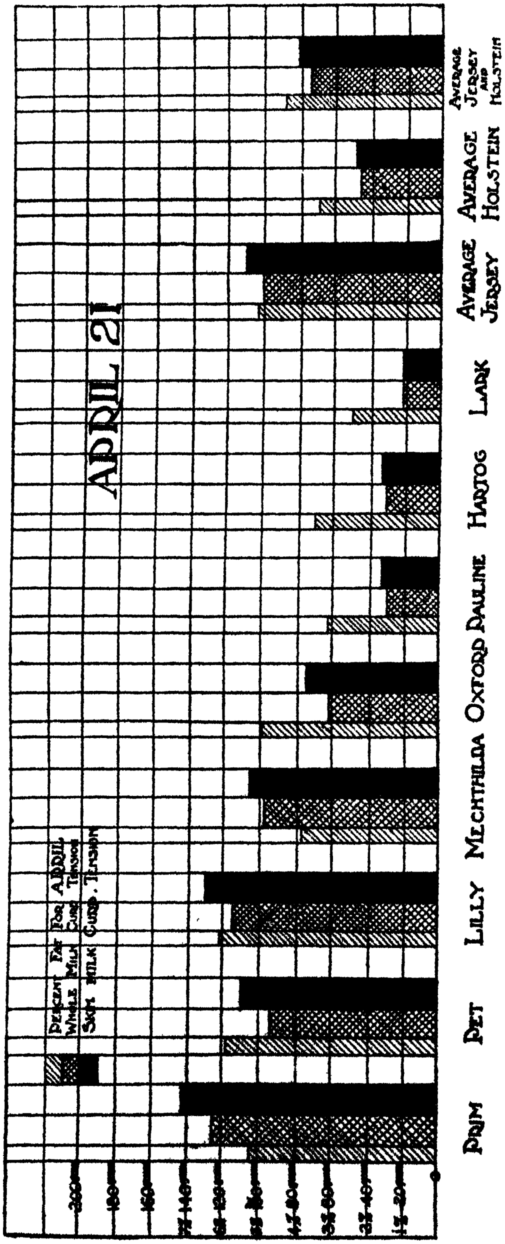

FIG. 10. GRAPH SHOWING EFFECT OF REMOVAL OF FAT CONTENT OF MILK ON THE MILK CURD TENSION OF JERSEY AND HOLSTEIN COWS FROM THE UTAH AGRICULTURAL COLLEGE DAIRY HERD ON APRIL 21, 1923

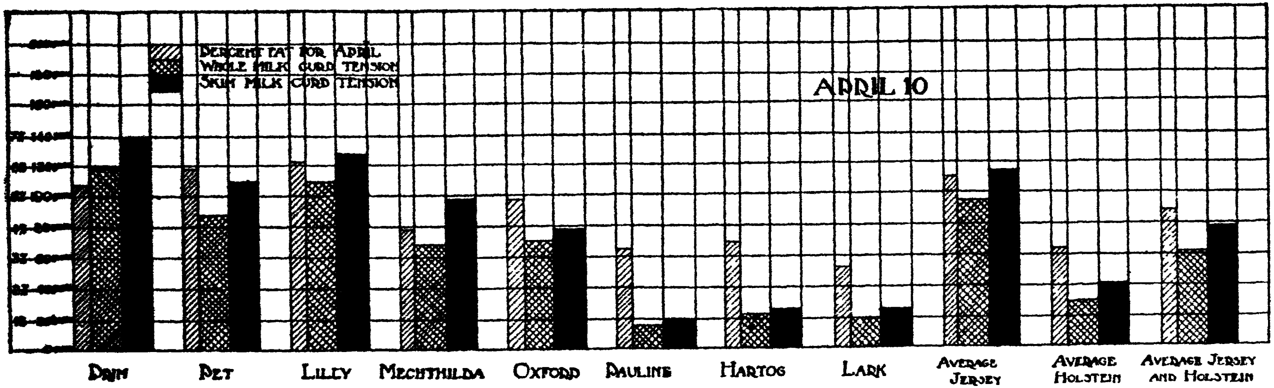

FIG. 11. GRAPH OF THE MILK CURD TENSION OF JERSEY AND HOLSTEIN COWS BEFORE AND AFTER REMOVAL OF FAT ON APRIL 10, 1923

Since the objection might be raised that the removal of the "slime" from the milk in separation might remove constituents other than fat which would effect curd tension a later experiment was outlined to further test this point.

TABLE 1

Curd tension of milk before and after removal of the fat content of the same

NAME OF COW	AVERAGE PER CENT OF FAT IN MILK	CURD TENSION ON APRIL 10		CURD TENSION ON APRIL 21	
		Whole milk	Skim milk	Whole milk	Skim milk
Hartog	3.5	22	25	30	33
Lark	2.7	19	23	22	22
Lilly	6.1	109	132	117	131
Mechthilda	3.8	67	98	99	104
Nemo	6.2	87	103	86	91
Oxford	5.0	65	68	63	75
Pauline	3.2	17	18	33	35
Pet	5.9	88	111	95	113
Pontiac	3.8	54	57	52	62
Prim	5.3	118	140	127	143
Rachel	3.5	51	64	48	59
Rill	4.5	62	67	62	73

TABLE 2

Curd tension of milk before and after removal of fat content as well as on re-mixed fat and milk

NAME OF COW	WHOLE MILK	PREPARED MILK	SKIM MILK
Lark	24	20	24
Lilly	118	106	139
Mechthilda	87	87	122
Oxford	61	66	88
Pauline	48	50	62
Rill	62	56	73

The samples of milk were separated as before and the amount of cream required to bring up the fat content of the skim milk to that of the original whole milk was added. The curd tests were then made on this prepared milk, on the whole milk, and on the skim milk. Table 2 shows the results obtained.

From this table it is evident that the removal of fat content from the milk is responsible for hardening the curd since the remixed milk checked with the milk before separation.

IS CURD CHARACTER OF THE MILK A TRANSMITTED CHARACTERISTIC?

Whether or not the curd character of the milk is a transmitted characteristic can not at this writing be definitely shown. Our results with 3 cows, however, would indicate that it was transmissible. From the graphs one can see that the milk from Hartog and her 2 daughters, Pauline and Lark, was softer in curd than any of the other milks. About eight years ago Hartog's mother's milk was used to feed a delicate infant with splendid results. This would indicate that the curd characteristic had been transmitted for two generations. It may be possible to breed for softness of curd in milk with success.

THE CAUSE OF CURD VARIANCE IN COWS' MILK

Work is now being done on the reason for this wide variance in cows' milk. It may be due to a variation in the mineral content. That there is a wide variance in the mineral content of cows' milk has been shown by recent investigators. An increase in the sodium or potassium salts of the milk would have a tendency to soften the curd, while conversely a decrease in the soluble calcium salts would produce a like result. Work is now in progress on the calcium content of the milk, but the results so far would not warrant a positive statement regarding the relation of calcium content of milk to curd texture.

PRACTICAL APPLICATION OF CURD TEST

The results thus far obtained would indicate that this test may find practical application in selecting those cows giving milk especially adapted to the needs of infants and invalids. It is planned to test several dairy herds in the state and collect data on the use of these special soft-curded baby milks on the nutrition of infants. It is also possible that the harder curded milks will be superior for cheese-making. The extent to which the curd character of the milk can be influenced by a variation in the feed of the cows is also being checked by this test.

SUMMARY

A curd test has been developed whereby the degree of hardness of the curd of cows' milk can be determined. By means of this test the dairy herd of the Utah Agricultural College has been classified on the basis of the curd character of the milk. This classification extends over a period of more than six months and includes cows in all stages of lactation.

As a result of these studies it has been shown that each cow had an individual milk curd character that was fairly regular throughout her entire lactation period, but in general it hardened during the first part of the period to soften again toward the latter end of the normal lactation period. The curd tension of the harder curded milk was sometimes as much as 10 times as great as the curd tension of the softer curded milk.

The individual difference in curd character was independent of breed and fat content of the milk. The Jersey breed as an average, however, had a much harder curded milk than the Holstein breed, yet some of the Jerseys had a softer curded milk than the harder curded Holsteins.

ACKNOWLEDGEMENTS

The author desires to express his appreciation to Prof. William Peterson, Director of the Utah Agricultural Experiment Station, for advice and encouragement as well as to Dr. F. S. Harris, former Director of the Utah Agricultural Experiment Station, for his interest and counsel. The author further wishes to express his indebtedness to Miss Blanche Cooper and Mr. Angus M. Maughan for their aid in analytical work on the mineral content of the milk and to Mr. Alwyn Sessions for running curd tests and collecting samples.

HOW THE ADVANCE OF THE PERIOD OF LACTATION AFFECTS THE MILK FLOW

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Upon calving, the rate of milk secretion of the dairy cow gradually increases for a time and then gradually decreases until the animals become dry. The cause of the gradual increase in the flow of the milk after calving is undoubtedly due to the improving condition of the animal following parturition, increasing consumption of food, and to the gradual perfection of the mammary gland.

The object of this paper is to present data on the time of maximum production and to show that the percentage decline of milk secretion with the advance of the stage of lactation is constant.

I. TIME OF MAXIMUM MILK PRODUCTION

It is well known that maximum milk production is usually reached during the first or second month of lactation, but a search of the literature failed to show when the exact peak is reached. Haecker (1) of the Nebraska Station found that nine-tenths of the cows whose records were studied made their best records during the first ten weeks.

In order to obtain further information on this problem 80 Holstein-Friesian records from the dairy herd of the University of Missouri were selected and the average daily milk production for the first ninety days determined. As milk production is notably affected by pasture, heat, flies, etc., during the summer months, only those records were chosen which came entirely between September 1 and May 1. Neither the age of the animals nor their condition at calving time were considered.

The records were divided as to the number of milkings per day. Of the 80 records studied 40 were those of cows milked twice per day, 32 of cows milked three times per day, and 8 of cows milked four times per day.

The results are presented in figure 1. It will be seen that the cows milked twice per day reach their peak of production on the fifteenth and sixteenth days after calving. The cows milked three times per day reach a peak on the eighteenth day while the cows milked four times per day did not reach their maximum production until the twenty-eighth day after calving.

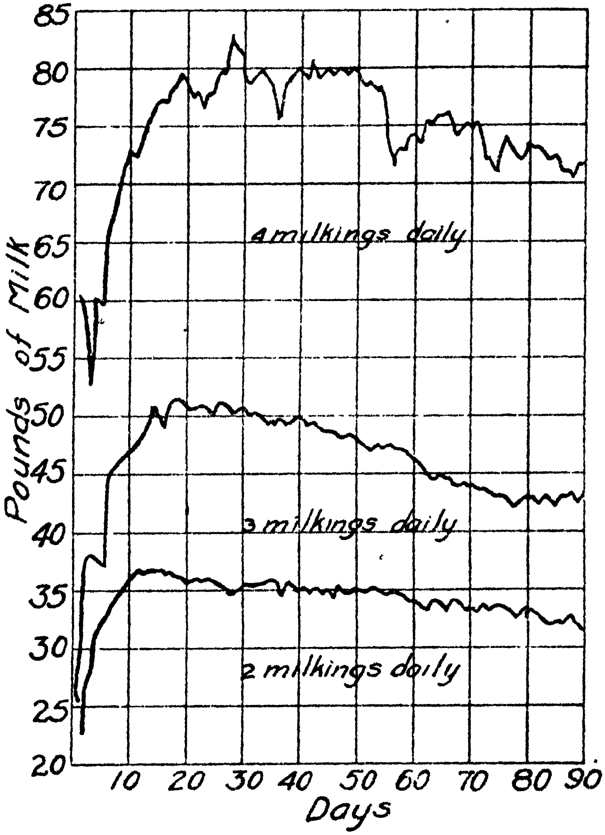

FIG. 1. THE TIME OF MAXIMUM MILK PRODUCTION OF HOLSTEIN-FRIESIAN COWS

It appears from this that the frequency of milking and the amount of milk produced are the most important factors in governing the time of maximum milk production. This may be explained as being due to the length of time necessary to get a high producing cow upon full feed.

II. THE DECLINE OF MILK PRODUCTION

The decline of milk secretion after reaching maximum production is well known to be fairly uniform. The length of lactation period, however, varies with the individual animal, the feeding and management, the time of breeding, and certain hereditary qualities. Highly developed dairy cows if left farrow will often continue to produce milk for several years, while beef cows and animals of inferior dairy qualities will dry up within a few months even when furnished with an abundance of feed.

In previous studies (2) (3) on the effect of the stage of lactation on the milk yield, where the percentage was based on the production of the previous month, more or less irregular decreases have been found. It has never been shown, however, that there was any definite way in which milk production decreased from month to month during the lactation period irrespective of breed or the amount of milk produced by the animal.

From a physiological standpoint it seems reasonable that so important a function as milk secretion must be regulated in some definite way when an abundant food supply is available. In connection with other studies being made, a large amount of data showing the monthly declines in milk production was available. This data was studied to determine if there was any regularity in the way milk secretion declined from month to month during the lactation period.

We have found that there is indeed such a regularity or law governing the decline of milk secretion with advance of the period of lactation. This law may be expressed by saying that each months production after the second month is a constant percentage of the preceding months production. In the case of farrow Guernsey cows, where the factor of pregnancy is eliminated, each months production is about 94 per cent of the preceding months production. This idea may be expressed mathematically by the equation

$$M_t = M_o e - kt$$

where M_t is the milk produced during any month of the lactation period t. M_o is the initial theoretical production and k is the persistency constant while e is the base of natural logarithms.[1]

TABLE 1

Decline of milk secretion with the advance of the period of lactation

MONTH OF LACTATION	(1) GUERNSEY COWS, AVERAGE 8215 LACTATION PERIODS		(2) GUERNSEY COWS, AVERAGE 900 LACTATION PERIODS		(3) GUERNSEY COWS, AVERAGE 370 LACTATION PERIODS		(4) ALL BREEDS, AVERAGE 1143 LACTATION PERIODS		(5) JERSEY COWS, AVERAGE 305 LACTATION PERIODS		(6) HOLSTEIN COWS, AVERAGE 95 LACTATION PERIODS		(7) SCRUB COWS, AVERAGE 32 LACTATION PERIODS	
	Daily milk yield	Monthly percentage decline	Daily milk yield	Monthly percentage decline	Daily milk yield	Monthly percentage decline	Daily milk yield	Monthly percentage decline	Daily milk yield	Monthly percentage decline	Daily milk yield	Monthly percentage decline	Daily milk yield	Monthly percentage decline
	lbs.		*lbs.*		*lbs.*		*lbs.*		*lbs.*		*lbs.*		*lbs.*	
1	33.3						46.3		30.0		39.6		20.4	
2	34.3	103.0	35.1		35.1		45.4	98.1	29.4	98.0	40.3	101.8	19.0	93.1
3	32.3	94.1	33.3	94.9	32.8	93.4	41.9	92.3	27.9	94.9	38.9	96.5	16.0	84.2
4	29.9	92.6	31.3	93.9	30.4	92.7	38.9	92.8	25.9	92.8	36.5	93.8	14.0	87.5
5	28.1	94.0	29.3	93.0	28.7	94.4	36.2	93.1	24.2	93.4	33.9	92.9	12.0	85.7
6	26.4	94.0	27.8	94.9	27.3	95.1	33.5	92.5	22.7	93.8	32.5	95.9	9.7	80.8
7	24.9	94.3	26.4	95.0	25.9	94.9	30.9	92.2	21.4	94.3	30.8	94.8	8.0	82.5
8	23.7	95.2	25.1	95.1	24.3	93.8	27.5	89.0	20.6	96.3	29.3	95.1	7.0	87.5
9	22.4	94.5	23.8	94.8	22.6	93.0	24.4	88.7	19.5	94.7	27.9	95.2	5.4	77.1
10	21.0	93.8	22.5	94.5	20.6	91.2	20.4	85.7	18.6	95.4	25.4	91.0	3.7	68.5
11	19.5	92.9	21.5	96.4	17.9	86.9			17.3	93.0	23.2	91.3		
12	17.9	91.8	20.6	95.8	15.6	87.2			17.3	100.0	20.1	86.6		

(1) The records were compiled from the Guernsey Advanced Registry without selection.

(2) Only farrow cows were included.

(3) Only cows bred the third and fourth months were included.

(4) Compiled by Prof. F. W. Woll from the records of the Wisconsin and California Dairy Cow Competitions, Hoard's Dairyman, February 9, 1923, p. 109.

(5) The records were compiled from Jersey cows tested in Missouri.

(6) The records were compiled from Holstein cows owned by the University of Missouri.

(7) The data for the scrub cows was taken from chart 2, Iowa Agr. Exp. Sta. Bulletin 188.

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[1] A theoretical discussion is given in the Journal of General Physiology, v, no. 4, 441.

As will be seen from table 1, this constancy in the percentage decline of milk secretion of the date available holds true to a remarkable degree. The Guernsey cow produces about 94 per cent of the previous month's production throughout the entire period of decline in milk secretion. There is a slightly larger percentage decrease during the last two or three months which is undoubtedly due to advanced pregnancy as the group of farrow cows do not show this decline at all, while another group of cows bred the third and fourth months show a more rapid percentage decline during the last three months of lactation.

The data compiled by Woll (4) consist of ten months records with definite calving requirement. The decline during the last several months is undoubtedly also due to pregnancy. The data for the Jerseys and Holsteins also show a very close agreement with the expected decline. Data on a limited number of scrub cows show a more rapid but fairly constant monthly percentage decline. This would naturally be expected of cows with short lactations.

SUMMARY

Data was presented showing the time of maximum milk production of Holstein-Friesian cows. It was suggested that the frequency of milking and the amount of milk produced are the most important factors governing the time of maximum production.

The percentage decline of milk secretion with the advance of the period of lactation was shown to be fairly constant. A slightly greater percentage decrease during the last two or three months of lactation was shown to be due to advanced pregnancy.

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SWEETENED CONDENSED MILK

I. BACTERIAL THICKENING

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For some years there have come to the attention of the writers samples of sweetened condensed milk which had been refused by the trade on account of having become extremely thick. In many cases the product is solid, in others it will barely flow when the cans are inverted, though sometimes it is merely clotted. Generally, there is a characteristic odor, not entirely unpleasant but which might be described as fruity; the taste is disagreeable. The acidity of the product is considerably above normal. No alteration in the color can be noticed and there is no evolution of gas. If the thickened product be vigorously stirred it becomes somewhat thinner but almost immediately sets to a glue-like mass.

When a portion of this milk is diluted with water and heated, a separation of curd takes place. By this test the kind of thickened milk which is here being described can be readily distinguished from thickening in condensed milk which results from physical causes such as has been studied by Rogers, Deysher and Evans (1). Age, or storage at high temperature, or exposure to high heat cause thickening but aside from high viscosity there is no other similarity between such a product and that which becomes thick due to bacterial action. There is no increase in acidity and no unusual odor connected with heat or age thickened milk.

Bacterial counts on these thickened samples are very high, often more than a million per gram. The organisms are almost entirely of the cocci form. Inoculation of cultures of these into condensed milk with relatively low total solids content is found to produce in a week or two conditions similar to those found in the commercial samples.

Bacterial thickened milk has been found to occur most commonly in late spring and summer and also in shipments to tropical climates.

GENERAL BACTERIOLOGY OF CONDENSED MILK

Perhaps the first to make a study of the deterioration of condensed milk from the point of view of the bacteriologist was Cassedebat (2). He concluded from his observations, that changes in the product were not due to bacteria, since he failed to find any organisms either living or dead. Nothing but molds, he believed, would grow in it.

Beginning with Hope (3), however, more careful studies have been made of the bacteriology of sweetened condensed milk, and all investigators have reported finding it non-sterile. (See references 4 to 17.) Previous investigations have, in general established the following points: (*a*) In good condensed milk the total number of bacteria is relatively low, usually but a few hundred per gram, and (*b*) when such a product is inoculated with a culture of bacteria the organisms not only do not grow, but the count often becomes less with time. (*c*) In samples of low grade condensed milk on the other hand, where some decomposition has taken place, the bacterial counts have been found to run into the millions (*d*) the coccus forms predominating in most cases. (*e*) Pathogenic bacteria are nearly always absent.

Aside from the true bacteria there too have been found in condensed milk organisms of the torula class and molds. Pethybridge (18), Hammer (19), Cassedebat (2), Rogers, Dahlberg and Evans (20) and others have described defects due to these organisms.

Previous investigations on bacterial thickening in condensed milk

Greig-Smith (21) reported finding commercial samples of condensed milk which had become coagulated and in which cocci were growing in large numbers. There is little doubt but that the condition he observed is identical with that which forms the subject of this work. It is probable that Dugardin's (22) experience with condensed milk of high acidity is related to this defect.

Hunziker (23) discusses "thickened and cheesy condensed milk" also and points out that the condition can be prevented by the use of unusually large amounts of sugar in the manufacture.

For the preservation of the sweetened condensed milk, therefore, chief dependence is placed upon the high sucrose concentration, except that torulae and molds are apparently able to grow in concentrations of sugar even up to the saturation point, and defects caused by these organisms can be prevented only by guarding against their entrance into the product during manufacture. But the true bacteria, at least those of common occurrence, can probably be checked if the concentration of sugar is high enough. Almost any table of results of analyses of condensed milk show the wide variations in sugar content not only between different brands but between different samples of the same brand, and this is particularly shown by a recent report from the Connecticut Agricultural Experiment Station (24). This may explain, therefore, why the investigators have in some samples found bacteria growing luxuriantly while in others, organisms would not multiply even when the product was heavily inoculated with them.

EXPERIMENTAL

It was the purpose in this work to look at the problem particularly from the manufacturer's point of view, to determine what standardization is necessary to prevent thickening, and to learn, if possible, why the defect occurs especially in condensed milk manufactured and stored during the summer and in that marketed in the tropics.

A study of the cultural characteristics, habitat and distribution of the organism causing thickening has not been completed and will be reserved for future report. However, sufficient has already been done along this line to show that it is, indeed, widely distributed. It has been isolated from practically all samples of sweetened condensed milk purchased on the market, fortunately being dormant in the majority of cases.

It seemed certain that these cocci must come from the factory in which the product is being made, since the species is not sufficiently heat resistant to withstand the operation of processing and could not reach the finished product from the raw milk entering the factory. In order to obtain what might be present in a milk plant which would grow in sweetened condensed milk an inoculum was obtained by mixing material taken from different places in a factory such as the packing of Jensen coolers, wall and floor scrapings, some slime from a cheese curing room and so on. A sample of normal condensed milk containing about 74 per cent total solids was reduced with water to 70, 65 and 60 per cent total solids. Into these portions a mixture of the above material was inoculated and incubated for about two weeks. At the end of that time all samples were nearly solid and had the typical fruity odor which had already been experienced in the commercial samples. Upon examination it was found that coccus forms were present almost exclusively which when reinoculated into condensed milk a little low in total solids grew, accompanied by thickening of the product, development of the fruity odor and an increase in acidity. It would seem from this that condensed milk diluted down to 60 to 70 per cent total solids acts practically as a differential medium for these organisms.

Acidity produced in condensed milk by the organism

In normal fresh condensed milk the acidity calculated as lactic acid usually runs between 0.23 and 0.33 per cent. Commercial samples which show evidences of growth of the thickening organisms have been found to run as high as 0.75 per cent. Laboratory samples of low solids content inoculated with the organisms often reach more than 1 per cent. These facts suggest acidity titration as a means of estimating the relative growth of the organisms in different samples, and such determinations were accordingly made in all tests. The acidity in all experiments is calculated in terms of the percentage of lactic acid.

Growth of the thickening organism in condensed milk of different standardizations

Experiment 1. Three variables were taken into account in this experiment: percentages of sucrose, milk solids and water. In order to prepare samples for inoculation the following procedure

TABLE 1

SAMPLE	MILK SOLIDS	SUCROSE	WATER	SUGAR RATIO	ODOR	CONSISTENCY	ACIDITY	CONCLUSIONS AS TO GROWTH
	per cent	*per cent*	*per cent*					
1	26.0	46.6	27.4	63.0	OK	OK	0.238	0
2	24.5	47.5	28.0	62.9	OK	OK	0.247	0
3	27.1	45.8	27.1	62.8	OK	OK	0.256	0
4	29.6	44.2	26.2	62.8	OK	OK	0.305	0
5	32.5	42.4	25.1	62.8	OK	OK	0.279	0
6	31.0	43.3	25.7	62.7	OK	OK	0.360	?
7	24.1	46.9	29.0	61.8	OK	OK	0.232	0
8	24.1	46.9	29.0	61.8	OK	OK	0.232	0
9	25.6	45.9	28.5	61.7	OK	OK	0.267	0
10	25.6	45.9	28.5	61.7	OK	Heavy	0.337	+
11	26.7	45.2	28.1	61.6	OK	OK	0.283	0
12	26.7	45.2	28.1	61.6	OK	OK	0.275	0
13	29.2	43.6	27.2	61.5	OK	OK	0.284	0
14	29.2	43.6	27.2	61.5	Fruity	Heavy	0.338	+
15	30.6	42.7	26.7	61.5	Fruity	Solid	0.481	++
16	30.6	42.7	26.7	61.5	Fruity	Solid	0.558	++
17	32.1	41.8	26.1	61.5	OK	Heavy	0.373	+
18	32.1	41.8	26.1	61.5	OK	Solid	0.452	++
19	33.5	40.8	25.7	61.3	Fruity	Solid	0.252	+
20	23.7	46.3	30.0	60.6	OK	OK	0.311	+
21	25.3	45.2	29.5	60.5	OK	Heavy	0.311	+
22	26.4	44.5	29.1	60.4	OK	Heavy	0.365	+
23	28.7	43.0	28.3	60.3	OK	Solid	0.369	+
24	30.1	42.1	27.8	60.2	Fruity	Solid	0.463	++
25	31.6	41.2	27.2	60.2	Fruity	Solid	0.482	++
26	33.0	40.3	26.7	60.1	Fruity	Solid	0.387	++
27	33.0	40.3	26.7	60.1	Fruity	Solid	0.400	++
28	34.3	39.4	26.3	60.0	Fruity	Solid	0.360	++
29	23.4	45.6	31.0	59.5	Fruity	Heavy	0.292	+
30	24.9	44.6	30.5	59.4	Fruity	Heavy	0.352	+
31	26.0	43.9	30.1	59.3	Fruity	Solid	0.345	++
32	28.4	42.4	29.2	59.2	Fruity	Solid	0.459	++
33	29.7	41.5	28.8	59.0	OK	Heavy	0.302	+
34	31.2	40.6	28.2	59.0	Fruity	Solid	0.522	++
35	32.5	39.7	27.8	58.8	Fruity	Solid	0.512	++
36	33.8	38.8	27.4	58.6	Fruity	Solid	0.525	++
37	33.8	38.8	27.4	58.6	Fruity	Solid	0.572	++
38	35.7	36.9	27.4	57.4	Fruity	Solid	0.624	++
39	27.6	41.2	31.2	56.9	Fruity	Solid	0.594	++
40	35.2	36.4	28.4	56.2	Fruity	Solid	0.728	++
41	23.6	42.3	34.1	55.4	Fruity	Solid	0.550	++
42	36.5	34.3	29.2	54.0	Fruity	Solid	0.792	++
43	23.0	41.2	35.8	53.5	Fruity	Solid	0.644	++
44	37.5	32.6	29.9	52.2	Fruity	Solid	1.027	++

was followed: (*a*) About 18 pounds of sucrose was added to 100 pounds of whole milk; this was condensed down in a small vacuum pan to a high consistency. Upon analysis the batch was found to contain 43.0 per cent sucrose, 33.0 per cent milk solids and 24 per cent water. (*b*) Similarly a batch was prepared by adding sucrose at the rate of 2 pounds per 100 pounds of milk and condensing down. This was found to contain 10.0 per cent sucrose, 52.5 per cent milk solids and 37.5 per cent water. (*c*) A solution of sucrose in water was prepared containing 64 per cent sucrose. By mixing these three batches in various proportions a variety of standardizations could be obtained.

The various mixtures were inoculated with a liberal amount of a bouillon culture of the organism and the samples incubated at 30°C. for thirty-five days. At the end of this period the samples were inspected for consistency and odor and the acidity was determined, from which, conclusions were drawn concerning the growth of the organism. In table 1 are found the results. In the last column no growth is indicated by 0, slight growth, +, heavy growth ++.

From the percentages of sugar and of water in each sample there is calculated the percentage of sugar in solution in the water, disregarding for the moment other constituents, for instance, in sample 1, the percentage of sucrose is 46.6 which is 63.0 per cent of 74.0, the latter being the sum of the percentages of sucrose and water. For sake of convenience this will be called the "sugar ratio." In one column are found these ratios and the whole series is arranged in order of decreasing values.

Inspection of the table shows that at a sugar ratio of about 61.5 comes the dividing line, though it is not very sharp. At higher values growth seems not likely to take place while at all points below, growth is practically certain. At and near this line the milk solids is seen to vary considerably in the various samples, apparently without affecting the growth of the organism. It would seem, therefore, that the amount of sucrose in proportion to the water is the important factor in affecting the growth of thickening organisms.

No doubt this is correct generalization as far as practical application is concerned. However, from the milk solids a considerable amount of lactose is in solution, and it is likely that the osmotic pressure due to the soluble lactose has an effect additive to that of the sucrose; both, then, would contribute toward inhibiting bacterial growth. But, in condensed milk the water is always saturated with respect to lactose, a large amount of insoluble phase being present, therefore, even though the milk solids varies in these experiments the percentage of lactose in solution in the water is always the same for a given temperature. As the other constituents of the milk cannot affect the osmotic pressure greatly, variation of milk solids in the standardization should not change the potency of the product to check bacterial growth.

Experiment 2. Condensed milk samples of different standardizations were prepared in this experiment in the same way that was described under experiment 1. The culture employed for inoculation was the same organism that was used in the previous experiment but it had been carried in the laboratory for about 4 months and was used without any particular effort to get it into an invigorated condition. The same proportions of culture were added as in the former experiment.

Results obtained here were of somewhat different order from those in the previous experiment. Although the time of incubation was three times that in experiment 1, much less activity was manifested by the organism, less acid was produced at all concentrations and very few of the samples had increased in viscosity more than a little. The line dividing the standardizations with respect to growth or no growth was found to be between the sugar ratios 59 and 60.

Again it was concluded that a variation in percentage of milk solids has no influence on the growth of the thickening organism. Consequently, in all later experiments only the relations of sucrose to water were taken into account, the milk solids being allowed to vary without control.

Experiment 3. A quantity of condensed milk was divided and diluted with water to successive standardizations. Each portion was further divided into two parts one being inoculated with a culture of the thickening organism invigorated by frequent

TABLE 2

SAMPLE	SUCROSE	WATER	SUGAR RATIO	CONSISTENCY AT END OF						ACIDITY AT END OF 31 DAYS	
				6 days		16 days		31 days			
				Invigorated	Non-invigorated	Invigorated	Non-invigorated	Invigorated	Non-invigorated	Invigorated	Non-invigorated
	per cent	*per cent*									
1	44.30	25.60	63.37	Normal	Normal	Normal	Normal	Normal	Normal	0.477	
2	44.16	25.94	63.00	Normal	Normal	Normal	Normal	Normal	Normal	0.567	0.423
3	43.95	26.09	62.75	Normal	Normal	Normal	Normal	Normal	Normal	0.639	
4	43.81	26.28	62.50	Normal	Normal	Normal	Normal	Normal	Normal	0.855	0.495
5	43.67	26.48	62.25	Normal	Normal	Heavy	Normal	Heavy	Normal	0.885	
6	43.53	26.68	62.00	Normal	Normal	Heavy	Normal	Heavy	Normal	0.900	0.630
7	43.39	26.87	61.75	Heavy	Normal	Solid	Normal	Solid	Normal	0.891	
8	43.24	27.06	61.50	Heavy	Normal	Solid	Normal	Solid	Normal	0.954	0.495
9	42.96	27.46	61.00	Heavy	Normal	Solid	Normal	Solid	Heavy	1.008	0.567
10	42.68	27.86	60.50	Heavy	Normal	Solid	Heavy	Solid	Heavy	1.053	0.684
11	42.40	28.26	60.00	Heavy	Normal	Solid	Solid	Solid	Solid	1.161	0.765
12	41.90	29.12	59.00	Solid	Heavy	Solid	Solid	Solid	Solid	1.269	0.837
13	41.40	29.98	58.00	Solid	Solid	Solid	Solid	Solid	Solid	1.287	0.801

transfers in bouillon and the other with an old culture which had been in the laboratory for some months without being transferred. All samples were incubated at 30°C. and inspections made at the end of six, sixteen and thirty-one days. In table 2 will be found the analysis of each sample together with the results of inspection.

The results obtained in this experiment as well as in experiments 1 and 2 give evidence that an invigorated culture of the organism grows in sweetened condensed milk much more rapidly and at a much higher sugar concentration than the same organisms in a less invigorated form. At the end of the incubation period the invigorated organism had thickened samples up to the sugar ratio 62.25 while in samples inoculated from the old culture thickening did not take place above 61.

These results also show that considerable bacterial activity had taken place in samples of sugar concentration above the point where thickening ceased. This was shown by the fact that considerable acid was produced (the acidity of the samples at the beginning was 0.42 per cent), and the fact that when quantities of these samples were heated with water a curd separated out.

Judging from acidity determinations and the hot water test all growth was checked in the samples inoculated with noninvigorated cultures at sugar ratios between 62.5 and 63 while the invigorated organism was active at all concentrations including the highest one in the experiment 63.25. It is evident, therefore, that the particular culture used here was more active than the one used in experiment 1 and in consequence the series of samples was not run to sufficiently high sugar ratios to find at what point the growth was absolutely inhibited. Accordingly another experiment was carried out starting with a batch of unusually high condensation.

Experiment 4. A special batch of sweetened milk was condensed to a high consistency and found to contain 46.4 per cent sucrose and 24.7 per cent moisture. As in the preceding experiment this was brought down by adding increasing quantities of water to successive portions. At each standardization the samples were inoculated with an invigorated culture. Every effort was made to get the organism in the highest possible state of invigoration using as a medium skim milk containing 2 per cent sucrose. All samples were incubated at 30°C. for forty-three days, though by accident the temperature of the incubator was at about 20°C. for seven days of this time. In table 3 are given the chemical compositions of the batches together with the inspections made at the end of the incubation period. The coagulation test was applied by adding to a small quantity of the sample about four times as much water and heating to boiling.

TABLE 3

SAMPLE	SUCROSE	MOISTURE	SUGAR RATIO	CONSISTENCY	FRUITY ODOR	COAGULATION TEST	ACIDITY
	per cent	*per cent*					
Check	46.40	24.70	65.25	Normal	None	None	0.270
1	46.40	24.70	65.25	Normal	None	None	0.252
2	46.21	25.00	64.88	Normal	None	None	0.252
3	46.03	25.30	64.53	Normal	None	None	0.333
4	45.86	25.60	64.18	Heavy	Slight	Slight	0.333
5	45.66	25.89	63.81	Heavy	Slight	Slight	0.396
6	45.31	26.47	63.12	Heavy	Strong	Slight	0.513
7	45.13	26.76	62.77	Solid	Strong	Strong	0.612
8	44.96	27.04	62.44	Solid	Strong	Strong	0.513
9	44.78	27.32	62.10	Solid	Strong	Strong	0.630
10	44.44	27.85	61.47	Solid	Strong	Strong	0.693
11	44.27	28.16	61.12	Solid	Strong	Strong	0.621
12	43.77	28.96	60.18	Solid	Strong	Strong	0.684
13	43.44	29.50	59.55	Solid	Strong	Strong	0.675

It is concluded from these results that there is no sharp dividing line at which all growth of the organism ceases. The most objectionable evidence of growth, the solidification of the product, was stopped between the sugar ratios 62.77 and 63.12. Somewhat less thickening takes place from that point up to between 64.18 to 64.53, though judging from the acidity determinations there had been some growth of the organism even at the latter point. Further proof of this will be given under a discussion of the inversion of sucrose in these samples.

Bacterial counts were made on the samples from time to time throughout the experiment. The results were quite irregular. It was shown, however, while the numbers at first increased, that before the conclusion of the experiment the counts in all samples had been rapidly becoming lower. There is no possibility, therefore, that different conclusions would have been drawn had the incubation period been longer.

Effect of temperature on the growth of the organisms

Under many conditions it was observed that cultures of the thickening organisms grew more vigorously at 30°C. or above, than at normal room temperatures, though data from only one experiment are available for presentation.

Experiment 5. Bouillon was prepared with quantities of sucrose varying from 5 per cent to 65 per cent. Inoculations were made with invigorated and noninvigorated cultures, and the samples were incubated at 20° and 30°. Observations were made as to acid production and bacterial growth at intervals from 24 hours to 80 days.

It was found that the noninvigorated bacteria would not grow and produce acid in sucrose above 40 per cent at 20° while at 30° they were active even in 55 per cent sucrose. Similarly, growth in the invigorated cultures was checked at 55 per cent sucrose at 20° while these organisms were active at 62 per cent sucrose at 30°. Observations showed also that the maximum activity was reached in all cases much sooner at 30° than at 20°.

These results prove that the optimum temperature for the growth of the organism is relatively high, also that the organisms can withstand and multiply in higher concentrations of sugar at the higher temperatures.

Destruction of sucrose and apparent increase in lactose caused by the activity of the thickening organism

On samples 1, 3 and 13 from experiment 3 (inoculations with invigorated cultures) sucrose and lactose determinations were made at the beginning and end of the incubation period. Sucrose was determined by applying the Clerget formula on polarizations obtained before and after inversion, and lactose by running the regular reduction procedure on the clear filtrates. The results were as follows:

SAMPLE	BEFORE INCUBATION		AFTER INCUBATION	
	Sucrose	Lactose	Sucrose	Lactose
1	44.30	12.35	36.43	16.86
3	43.95	12 25	38.81	15.13
13	41 40	11.63	36.15	19.05

Also the first 3 samples in experiment 4 were run for sucrose before and after incubation with the following results:

SAMPLE	SUCROSE BEFORE INCUBATION	SUCROSE AFTER INCUBATION
	per cent	*per cent*
1	46.40	46.41
2	46 21	46 20
3	46 03	45.40

From these results it is seen that the thickening organism attacks sucrose, part of it being inverted; since the formation of invert sugar, which is reflected in the apparent increase in lactose, is not sufficient to account for all the loss in sucrose (except in one case), no doubt some of the sucrose also is destroyed by the organisms.

DISCUSSION OF RESULTS

It has been found that in order to surely prevent growth of the organisms causing thickening in condensed milk under all conditions it is necessary that the sugar ratio be at least as high as 64.5. As the ratio falls below this figure the organism becomes more and more active until at about 63 a strong odor develops and actual solidification begins.

The government standard holds that sweetened condensed milk shall contain not less than 28 per cent milk solids. If for the sake of the safety the product is standardized at 28.5 per cent, this would leave 71.5 per cent for sucrose and water. In order to have a sugar ratio of 64.5 there should be, therefore, 64.5 per cent of 71.5 or 46.1 per cent sucrose with 25.4 per cent moisture. The total solids of this product would be 74.6 per cent. In condensed milk of this standardization no matter how highly invigorated the contaminating organism might be and no matter at what temperature the product is held there should be no trace of growth of the thickening organism.

Calculation on the basis of a sugar ratio of 63.5, at which point there should be a reasonable safety from the dangers of actual solidification and the development of disagreeable flavors, gives the following figures: sucrose 45.4 per cent, moisture 26.1 per cent, total solids 73.9 per cent.

These standardizations are considered necessary when the contaminating organism is in its most active form and where the contaminated product is to be exposed to comparatively high temperatures. On the other hand the experiments recorded in this paper show that when these two sets of conditions are less favorable, somewhat lower sugar ratios would equally well prevent the development of the defects which result from the activity of the thickening organisms. This will account for the fact that though much of the milk on the market is standardized lower than is here found to be safe yet it does not all become defective, even though in most cases it does contain the organism.

One commercial sample of condensed milk was found which at ordinary room temperatures (in winter) did not undergo any change, but on being placed in the incubator it very soon developed typical thickening. On analysis this sample was found to run 43.80 per cent sucrose and 25.80 per cent moisture. The sugar ratio was, therefore, 62.93. In this product the organism must have been present in fairly active form and though the sugar ratio was below the safety point it was still high enough to prevent thickening as long as the sample was at ordinary room temperature, while at higher temperatures luxuriant growth of the organism was permitted.

Since these organisms could never withstand the heat to which the product is exposed in the operation of condensation, the contamination must take place in the factory after condensation is completed. The organisms growing thus in secluded points in the manufacturing equipment would be more likely to become invigorated in late spring and summer when the temperatures are higher; at the same time the finished product is exposed to higher temperatures at this time of the year which would be particularly conducive to the activity of the organisms, though the latter condition would be equally fulfilled in shipments to torrid climates at any time of the year. Thesepoints are taken as explanations for the fact which the trade has observed that in the summer and in shipments to the tropics the phenomenon of thickening is most likely to take place.

It was found that under some conditions the thickening organism grows in condensed milk inverting some of the sucrose without altering the general appearance of the sample. For such a condition as this the control chemist should be on his guard. If some of the sucrose had been inverted then an analysis of the product does not show the quantity of sucrose originally added by the manufacturer. Unless special methods are followed the presence of invert sugar will throw the percentage of lactose too high. At the same time if the milk solids are determined either by subtracting percentage sucrose from total solids or by adding together the percentages of the various milk constituents then that figure will also be too high.

No doubt this will explain the abnormal results recorded by the Connecticut Experiment Station (24) where in some samples lactose was found extremely high and the sucrose correspondingly low.

Sweetened condensed skim milk

Though most of the work on the project of thickening has been done on condensed whole milk, a number of observations on condensed skim milk have shown that this product forms no exception to the theory just worked out.

With respect to milk solids the government standard for this product is the same as for whole milk—28 per cent. Assuming that sweetened condensed skim milk of this standardization is to be made there would remain 72 per cent for the sucrose and moisture. Taking a sugar ratio of 63.5, lower than which it is certainly not safe to go, there should be 45.72 per cent sucrose and 26.28 per cent moisture. Such a product would, therefore, contain 73.72 per cent total solids. It has been the experience of the writers and others, however, that such a product is extremely viscous when cold, so much so, in fact, that it could be handled only with great difficulty in the factory.

Two alternatives seems to have been followed by manufacturers; to make the product with 28 per cent milk solids and with sugar condense only to about 68 to 70 per cent total solids beyond which is not possible to go without the product becoming too thick to handle, or without regard for standardization adding sugar to the extent of about 18 per cent of the weight of skim milk and condensing down to the desired consistency.

Suppose in the first example there are 28 per cent milk solids, 42 per cent sugar and 30 per cent water. The sugar ratio would be 58.3. This figure is so far below the ratio necessary for preventing growth of the thickening organism that the product would be very likely to become decomposed through this agency. In fact, observation has shown that wherever such a product has been manufactured spoilage results in most cases.

If the manufacturer follows the other procedure, his product will contain usually about 24 per cent milk solids, 48 per cent sugar, and 28 per cent water. The sugar ratio would be, therefore, 63.15, a figure though not absolutely safe, yet with care in manufacturing and handling no great amount of spoilage would take place.

It is known that in many cases the manufacturer is following the latter method and thus ignoring the government standard. The results of the Connecticut Experiment Station show 3 out of 6 brands of skimmed condensed milk to be without doubt below the government standard; on account of the abnormal lactose values it is impossible to judge concerning the remainder.

SUMMARY

The organism causing thickening in condensed milk is a coccus, which is capable of inverting and destroying sucrose, and producing considerable quantities of acid.

It is able to grow in fairly high sucrose concentrations, though its growth is checked if the concentration is high enough. It is able to withstand a much higher concentration of sugar when it is in an invigorated condition, also, at temperatures above normal room temperatures it is particularly active.

It has been isolated from factory equipment and probably it is at this point that the product is contaminated.

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A COMPARISON OF THE BABCOCK AND THE ROESE-GOTTLIEB (MOJONNIER) METHODS FOR DETERMINATION OF BUTTERFAT IN MILK

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The Babcock test for butterfat in milk has been used with but few changes since its discovery in 1890. During the period of over thirty years, however, several investigators have made comparisons as to its accuracy.

TABLE 1 (11)

Comparisons between the Babcock and gravimetric methods on whole milk

AUTHORITY	NUMBER OF COMPARISONS	AVERAGE OF ALL BABCOCK READINGS ABOVE AVERAGE OF ALL GRAVIMETRIC RESULTS	AVERAGE OF DIFFERENCES BETWEEN BABCOCK READINGS AND THE GRAVIMETRIC RESULTS*	ABSORBENT USED IN GRAVIMETRIC METHOD
Babcock (1)	30	0.011	±0.089	Asbestos
Snyder (2)	43	−0.026	±0.062	Asbestos
Farrington (3)	12§	0.050	±0.088	Asbestos
Farrington (3)	12§	−0.075	±0.093	Sand
Farrington (3)	12§	−0.129	±0.149	Paper
Connecticut Experiment Station (5)	32	within 0.01	6 differ over ±0.10	
Patterson (4)	20	−0.132	±0.153	Paper
Schutt (6)	32	−0.088†	±0.103§	
Heinrich (7)	27	−0.03‡		
Zehenter (8)	34	73.5 per cent within 0.05	3 differ over ±0.10	
Schrott-Fiechtl (9)	100	0.001	±0.076	Sand
Shiver (10)	49	0.067	±0.095	Paper

* Difference between comparisons on individual samples. This shows the average of the differences above or below the gravimetric method as contrasted with the previous column which shows the balance of these differences. The differences above and below the gravimetric method might be large and yet their balance be zero; thus showing too close an agreement between the two methods.

† From 12 of the comparisons.

‡ With 1500 revolutions, −0.22 with 800 revolutions. Diameter of wheel not given.

§ Same Babcock tests used.

A very complete summary of the work from 1890 to 1916 was prepared by Bailey (11).

A few other investigations had been made up to this time but the results were not altogether complete.

Julius Hortvet (12) in 1917 reported that the average of the results of ten different men showed that the Babcock test gave a reading of 0.04 per cent lower than the Roese-Gottlieb method.

Work carried out by Bailey (11) in 1916–1918 on 190 samples, showed fairly uniform results.

TABLE 2

Results of recent comparisons of the Babcock and Roese-Gottlieb methods for determination of fat in milk

AUTHORITY	YEAR REPORTED	NUMBER OF SAMPLES	METHODS USED	AVERAGE OF ALL BABCOCK READINGS ABOVE OTHER METHODS	PER CENT OF BABCOCK TESTS READING ABOVE ROESE-GOTTLIEB METHOD	VARIATIONS OF BABCOCK READINGS ABOVE ROESE-GOTTLIEB	AVERAGE OF ALL BABCOCK READINGS WITH GLYMOL BELOW OTHER METHODS
Bailey (11).....	1919	190	Grav.	0.060	92.1	−0.09 to +0.16	
Mojonnier and Troy (13).....	1922	14	Mojon.	0.022	64.3*	−0.15 to +0.16	
Mojonnier and Troy (13).....	1922	14	Adams	0.055	71.4	−0.11 to +0.21	
Hoyt (14).....	1922	28	Mojon.	0.116	100.0	+0.025 to +0.210	−0.025
Hoyt (14)......	1922	5	Mojon.	0.079	100.0	+0.025 to +0.115	−0.058
Hoyt (14).....	1922	5	Adams	0.091	80.0	−0.010 to +0.130	−0.046
Hoyt (14)......	1922	5	Asbestos	0.173	100.0	+0.110 to +0.220	+0.036
Dahlberg (15)...	1922	32	Mojon.	0.100	93.7*	−0.01 to +0.20	−0.09

* Reading on one sample same as Mojonnier.

Mojonnier and Troy (13) in 1922 reported some comparative work in which there was a rather wide variation in the results between the Babcock and Roese-Gottlieb (Mojonnier) methods.

Hoyt (14) and Dahlberg (15) presented reports to the California Creamery Operators Assn. at the Pacific Slope Dairy Products Show, Fresno, Calif., November 1922, showing that the average Babcock reading was considerably higher than the Roese-Gottlieb (Mojonnier) results. Since their results did not agree exactly, it was suggested that further work be undertaken.

OUTLINE OF WORK (BABCOCK METHOD)

The Babcock testing equipment, approved by the American Dairy Science Association (16) was used.

The 8 per cent milk test bottles were calibrated by the use of mercury, according to the standard of graduation which requires that 13.5471 grams of mercury shall fill the space equivalent to 5 per cent on the graduated column. Only bottles which were found to be completely accurate from the 0 to the 8 per cent mark and from the 2 to the 6 per cent mark were used. A small lens with a magnification of approximately × 3 was used to aid in obtaining the readings of the mercury.

All samples were obtained from a mixture of night and morning milkings, taken from the weigh can in the milk-receiving room of the University Farm Creamery. The samples were in perfect condition and were tested the same day as taken.

A one bottle torsion balance cream scale with a sensitivity of 10 milligrams was used and exactly 18 grams of milk, thoroughly mixed at a temperature of 60° to 70° F. was weighed into the test bottles.

Chemically pure sulphuric acid with a specific gravity of 1.82 to 1.83 was used at a temperature of 60° to 70°F.

A twenty inch Babcock Facile Steam turbine tester was used and the speed was held as closely as possible to 759 r.p.m. The tests were centrifuged, five, two, and one minutes, distilled water being added at a temperature of 190° to 200°F. They were then placed in a water bath for ten minutes at a temperature of 135° to 140°F. The readings were taken from the bottom of the lower meniscus to the extreme top of the upper meniscus by at least two members of the Dairy Industry Division. The readings were taken a second time, after the addition of glymol (colored mineral oil) to the tops of the fat columns. Average readings are recorded in table 3.

ROESE-GOTTLIEB (MOJONNIER) METHOD

The official Roese-Gottlieb analysis was obtained by using a Model-A Mojonnier tester. Approximately ten grams of milk was weighed directly into the fat extraction flasks. Only one

TABLE 3

Percentages of fat found in milk by the Babcock and the Mojonnier (Roese-Gottlieb) methods

SAMPLE	MOJONNIER			BABCOCK			BABCOCK (GLYMOL)		
	Original	Duplicate	Average	Original	Duplicate	Average	Original	Duplicate	Average
1	3.767	3.786	3.776	3.85	3.85	3.850	3.72	3.72	3.720
2	4.391	4.387	4.389	4.42	4.42	4.420	4.28	4.28	4.280
3	4.301	4.302	4.301	4.40	4.40	4.400	4.30	4.27	4.285
4	3.990	3.987	3.988	4.00	4.05	4.025	3.87	3.90	3.885
5	3.975	3.972	3.973	4.00	4.05	4.025	3.90	3.90	3.900
6	3.972	3.973	3.972	4.00	4.00	4.000	3.87	3.86	3.865
7	4.267	4.272	4.269	4.35	4.33	4.340	4.21	4.21	4.210
8	4.182	4.183	4.182	4.22	4.20	4.210	4.05	4.08	4.065
9	3.718	3.715	3.716	3.72	3.77	3.745	3.55	3.65	3.600
10	3.715	3.708	3.711	3.75	3.80	3.775	3.53	3.65	3.590
11	4.636	4.625	4.630	4.67	4.69	4.680	4.50	4.55	4.525
12	3.505	3.500	3.502	3.60	3.55	3.575	3.45	3.41	3.430
13	3.656	3.651	3.653	3.70	3.70	3.700	3.56	3.56	3.560
14	3.875	3.872	3.873	3.91	3.90	3.905	3.79	3.80	3.795
15	4.281	4.264	4.272	4.35	4.32	4.335	4.20	4.20	4.200
16	3.701	3.709	3.705	3.80	3.80	3.800	3.65	3.67	3.660
17	3.680	3.692	3.686	3.74	3.73	3.735	3.60	3.64	3.620
18	3.411	3.394	3.402	3.51	3.51	3.510	3.35	3.39	3.370
19	3.322	3.337	3.329	3.35	3.40	3.375	3.20	3.25	3.225
20	3.555	3.553	3.554	3.65	3.60	3.625	3.50	3.50	3.500
21	4.522	4.535	4.528	4.60	4.61	4.605	4.44	4.48	4.460
22	4.454	4.455	4.454	4.51	4.50	4.505	4.40	4.38	4.390
23	3.499	3.493	3.496	3.60	3.57	3.585	3.41	3.41	3.410
24	3.608	3.610	3.609	3.72	3.72	3.720	3.54	3.58	3.560
25	3.802	3.805	3.803	3.78	3.85	3.815	3.62	3.71	3.665
26	3.559	3.569	3.564	3.60	3.61	3.605	3.51	3.49	3.500
27	3.297	3.292	3.294	3.40	3.39	3.395	3.25	3.24	3.245
28	3.442	3.439	3.440	3.51	3.45	3.480	3.37	3.32	3.345
29	3.552	3.548	3.550	3.64	3.63	3.635	3.49	3.46	3.475
30	3.574	3.576	3.575	3.63	3.65	3.640	3.50	3.50	3.500
31	3.786	3.781	3.783	3.81	3.83	3.820	3.63	3.65	3.640
32	3.623	3.621	3.622	3.70	3.70	3.700	3.55	3.55	3.550
33	3.404	3.406	3.405	3.45	3.45	3.450	3.30	3.30	3.300
34	4.218	4.211	4.214	4.25	4.22	4.235	4.05	4.05	4.050
35	3.515	3.509	3.512	3.59	3.60	3.595	3.43	3.42	3.425
36	4.056	4.053	4.054	4.12	4.12	4.120	3.95	3.95	3.950
37	4.347	4.346	4.346	4.35	4.38	4.365	4.22	4.24	4.230
38	3.859	3.868	3.863	3.90	3.90	3.900	3.73	3.73	3.730
39	4.020	4.021	4.020	4.05	4.10	4.075	3.90	3.96	3.930
40	3.351	3.341	3.346	3.40	3.41	3.405	3.25	3.27	3.260

TABLE 3—*Continued*

SAMPLE	MOJONNIER			BABCOCK			BABCOCK (GLYMOL)		
	Original	Duplicate	Average	Original	Duplicate	Average	Original	Duplicate	Average
41	4.230	4.220	4 225	4 21	4 25	4.230	4.05	4 08	4 065
42	3.864	3.861	3 862	3 93	3.94	3.935	3.78	3.78	3.780
43	4.215	4.217	4 216	4 30	4.30	4.300	4 15	4.16	4.155
44	3 232	3.228	3 230	3 25	3 27	3.260	3 11	3.11	3.110
45	3 368	3 360	3 364	3 48	3 50	3.490	3 32	3.33	3.325
46	3 602	3.600	3 601	3.68	3 64	3.660	3 51	3 51	3.510
47	4.059	4 061	4 060	4.15	4.13	4.140	4 00	3 98	3 990
48	4 085	4 078	4 081	4 15	4 11	4 130	4 00	4 00	4 000
49	3.307	3 279	3.293	3 35	3 34	3 345	3 20	3 19	3 195
50	3 826	3 813	3 819	3 89	3 88	3.885	3 72	3.74	3.730
Averages..........			3 8222			3 8811			3 735

TABLE 4

Variations of percentages of fat in comparison of the Babcock and Roese-Gottlieb (Mojonnier) methods

SAMPLE	READING TO EXTREME TOP OF UPPER MENISCUS	READING WITH GLYMOL	SAMPLE	READING TO EXTREME TOP OF UPPER MENISCUS	READING WITH GLYMOL
1	+0 074	−0 056	27	+0 101	−0 049
2	+0 031	−0 109	28	+0 040	−0 095
3	+0 099	−0 016	29	+0 085	−0.075
4	+0 037	−0 103	30	+0 065	−0 075
5	+0 052	−0 073	31	+0 037	−0.143
6	+0 028	−0 107	32	+0.078	−0.072
7	+0.071	−0 059	33	+0.045	−0.105
8	+0.028	−0 117	34	+0.021	−0.164
9	+0 029	−0 116	35	+0 083	−0 087
10	+0 064	−0 121	36	+0.066	−0.104
11	+0 050	−0 105	37	+0 019	−0 116
12	+0 073	−0 072	38	+0 037	−0.133
13	+0.047	−0.093	39	+0 055	−0.090
14	+0.032	−0 078	40	+0 059	−0 086
15	+0 063	−0 072	41	+0 005	−0.160
16	+0 095	−0 045	42	+0 073	−0 082
17	+0 049	−0 066	43	+0 084	−0 061
18	+0.108	−0 032	44	+0 030	−0 0120
19	+0.046	−0 104	45	+0.126	−0 039
20	+0.071	−0 054	46	+0.059	−0 091
21	+0 077	−0.068	47	+0 080	−0.070
22	+0.051	−0.064	48	+0.049	−0.081
23	+0.089	−0.086	49	+0.052	−0.098
24	+0.111	−0.049	50	+0.066	−0.089
25	+0.012	−0.138			
26	+0.041	−0 064	Average....	+0 0588	−0.0870

sample was weighed at a time as it was thought that a slight error might be introduced if several pipettfuls were weighed at once. The reagents (distilled water, ammonia, alcohol, ethyl ether, petroleum ether) were of the best quality, as specified by Mojonnier and Troy (13). The Roese-Gottlieb process of fat extraction as described in the Mojonnier method (13) was used.

During the preliminary work, a comparison of the results from two extractions and three extractions was made, the third extraction making a slight increase of the third decimal point in the per cent of fat. It was also found that the addition of two drops of phenolphthalein indicator gave a similar increase. Consequently, the third extraction was omitted and the indicator added, since our object was to have the results represent as near the correct amount of butterfat as it was possible to obtain.

CONCLUSIONS

1. The Babcock test when read from the bottom of the lower meniscus to the extreme top of the upper meniscus, gave results which were higher than those obtained by the Roese-Gottlieb (Mojonnier) method. The average of 50 comparisons was found to be 0.0588 per cent.

2. The Babcock test gave readings which were higher in every case, the minimum variation from the Roese-Gottlieb (Mojonnier) being 0.005 per cent and the maximum 0.126 per cent.

3. When glymol (colored mineral oil) was added to the tops of the fat columns, an average reading was obtained which was 0.087 per cent lower than the average reading by the Mojonnier method.

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THE RELATIONSHIPS OF CONCENTRATION AND TIME TO THE TEMPERATURE OF COAGULATION OF EVAPORATED SKIM AND WHOLE MILK

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It is a well-recognized fact that the temperature of coagulation of an evaporated milk is dependent upon many factors. Among the factors that have been considered as influencing the temperature of coagulation are time of heating, acidity, H-ion concentration, homogenization, concentration of solids, time and temperature of forewarming, and shaking. Other factors sometimes mentioned are composition of the milk, stability of the proteins, and extraneous water present. These two latter are but secondary terms dependent upon other factors already mentioned. Some of these factors have been subjected to intensive study.

Sommers and Hart (1919) concluded that there is no consistent relation between the heat-coagulation temperature of milk and the titrable acidity, or between the heat coagulation and the H-ion concentration.

Rogers, Deysher and Evans (1921) found that the variation in the coagulation temperature of fresh mixed-herd milk is comparatively small and has little relation to the coagulation temperature of the same milk after evaporation. They also found that there is no definite relation between the coagulation temperature of evaporated milk and the H-ion concentration of the milk before sterilization. A very small increase in the acidity above the normal for a particular milk, however, will cause a distinct lowering of the coagulating temperature.

The latter found that forewarming temperatures much below 95°C. had little effect in raising the coagulating temperature; they also noted that forewarming for more than ten minutes (within certain limits) at 95°C. changed the stability of the milk but slightly.

Work by Sommers and Hart (1919) and also by Milroy (1915) upon the mineral constituents of milk seems to show that heat treatment results in the precipitation of calcium, the presence of which renders the milk unstable toward heat.

Many of the other factors mentioned have not been studied systematically. In order to determine to what extent reliance can be placed on results obtained upon herd milk handled in various ways, and held for varying lengths of time, we have undertaken a study of some of the factors already mentioned.

EXPERIMENTAL

The milk used in all cases was a composite sample of herd milk received daily from the Government Dairy Farm 1, Beltsville, Md. Previous to evaporation each sample was forewarmed by bringing it to 95°C. upon a steam bath and maintaining it there with constant stirring for ten minutes. The samples were then transferred into large balloon flasks and the evaporation was carried out under a vacuum of approximately 28 inches. The temperature at which concentration took place was probably never more than 45° or 50°C.

After evaporation the resulting product was standardized to the concentration desired, sealed in baby size cans, and sterilized in a pilot sterilizer at various temperatures and for various lengths of time, according to the plans of the experiment. In order to make the results as nearly comparable as possible it was necessary to choose an arbitrary rate of time in which to raise the temperature of the sterilizer to the temperature at which the sterilization was to be made. All sterilizations were therefore brought to 100°C. in ten minutes and the additional temperature was added within a period of five minutes. This procedure is not wholly accurate, since in some cases where high temperatures were used the milks were subjected to a greater total heat treatment before the sterilization was actually begun than in those cases where lower temperatures were used. It approximates factory conditions, however, and brings the product up to sterilization temperatures even when higher temperatures are used, thereby insuring greater accuracy in the time factor.

In several experiments upon an evaporated milk in the case of which the lengths of time chosen to bring the milk from 100°C. to the sterilization temperature were varied, it was found that the results were not markedly different. This would tend to show that the method is accurate unless the temperature of sterilization is exceedingly high.

SKIM VERSUS WHOLE MILK

It has been observed in the early part of our work that it was difficult to obtain checks upon various samples of milk received from day to day. The variations in coagulation temperature were too great to be accounted for by variations in the grade of milk. It was soon discovered that the different samples of milk did not contain exactly the same fat content, and inasmuch as the percentage of solids was calculated upon the total weight, any variation in the fat content would mean a variation in the percentage of water present after evaporation and consequently, perhaps, a great variation in the temperature of coagulation. Although such an experiment would have no great bearing upon the commercial processes, it was decided to ascertain to what extent the presence of fats influences the coagulating temperature of an evaporated milk.

Three samples of whole evaporated milk were prepared from a composite sample of herd milk with a fat content of 3.8 per cent. Another portion of this milk was partially skimmed (final fat content 1.2 per cent), and three samples of whole milk partially skimmed were evaporated to concentrations of 16.5, 18 and 19.5 per cent solids not fat. In each case the fat and total-solid contents were determined, and the percentage of solids not fat was calculated upon *the total weight of the whole milk minus the total weight of the fat.*

Figure 1 shows the results obtained on these two samples of milk.

This experiment tends to show that a slight variation in the percentage of fat present has little effect upon the coagulation temperature of milk.

It seemed, however, throughout our work that there was a slight difference between the temperature of coagulation of the evaporated whole milk and that of the evaporated skim milk, the former always ranging a trifle higher. This could be determined only by a series of tests at various concentrations. Such a series of determinations was made with milk received upon three consecutive days.

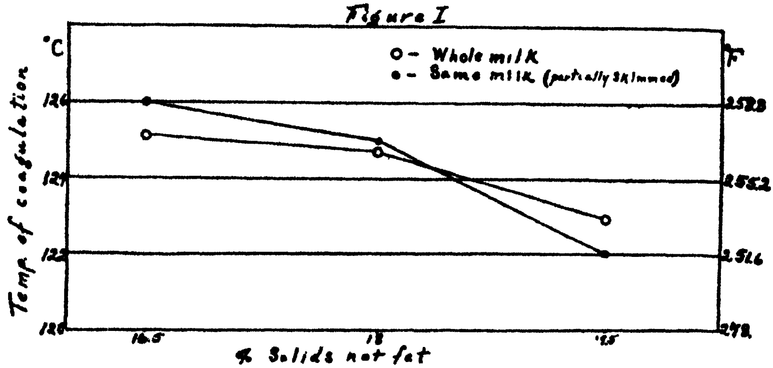

FIG. 1. EFFECT OF PARTIAL REMOVAL OF THE FAT IN MILK BEFORE EVAPORATION ON THE COAGULATION TEMPERATURE OF EVAPORATED MILK

For the results of this experiment, the reader is referred to figure 2, which also embodies the results for whole milk received on five consecutive days. These results seem to show clearly that the coagulation temperature of evaporated whole milk is a trifle higher than the coagulation temperature for evaporated skim milk, within the range of concentrations tried. Between the ranges of 16 and 20 per cent solids not fat, however, these differences are not great, the variations ranging from 1° to 1.5°C. for each percentage variation in concentration of solids not fat.

This difference in coagulating temperatures of whole and skim milks from the same sample is due, perhaps, to the absorption of heat by the fat present in whole milk. It has been found by Mr. Leighton, working in these laboratories, that with milks of high fat content there is considerably more heat absorption than with skim milks when both are subjected to the same temperatures in an oil bath.

In all cases, however, where the percentage of fat in two milks did not vary too greatly, the results were approximately the same for the evaporated milks containing the same percentage of solids not fat, within the concentrations recorded.

The percentage of fat is deducted in all cases and all calculations are made upon the *total weight minus the weight of the fat.*

CONCENTRATION VERSUS TEMPERATURE OF COAGULATION—UNIFORMITY OF GRADE OF MILK

It has been known for a long time that the temperature of coagulation of a protein is dependent to some extent upon the concentration. In a heterogeneous system such as is found in milk, however, the relation of the concentration to the temperature of coagulation will obviously not be the same as in the case of a pure protein.

Samples of whole milk were received upon 5 consecutive days, evaporated, and standardized to 6 different concentrations, not more than one sample of any one concentration being prepared on the same day.

This not only gives the relation between concentration and coagulation temperature, but gives also an indication of the reliability of our method of sterilization and an indication of the uniformity of the samples of herd milk from day to day.

Figure 2 shows the temperature of coagulation, for thirty minutes sterilization, of the various concentrations used.

This figure seems to indicate that the relationship of the change of coagulation temperature to concentration is not a constant, within the limits of concentration used. At higher concentrations there is a greater variation in the temperature of coagulation for every change of concentration than there is at the lower concentrations. The difference in temperature of coagulation for every 1 per cent difference in concentration when the percentage of solids not fat is between 16 and 26 per cent, in our method, seems to be about 1.25° to 1.50°C.

The variation in the temperature of coagulation of a certain concentration from day to day is not great in the milk received at this laboratory, as shown by points in the figure. At the higher concentrations the concordance of results is very good. At the lower concentrations results do not check so well. This can be accounted for when we consider that at higher temperatures (lower concentrations), in the method of sterilization used, there is a greater chance for error in bringing the product up to the temperature at which sterilization is to take place.

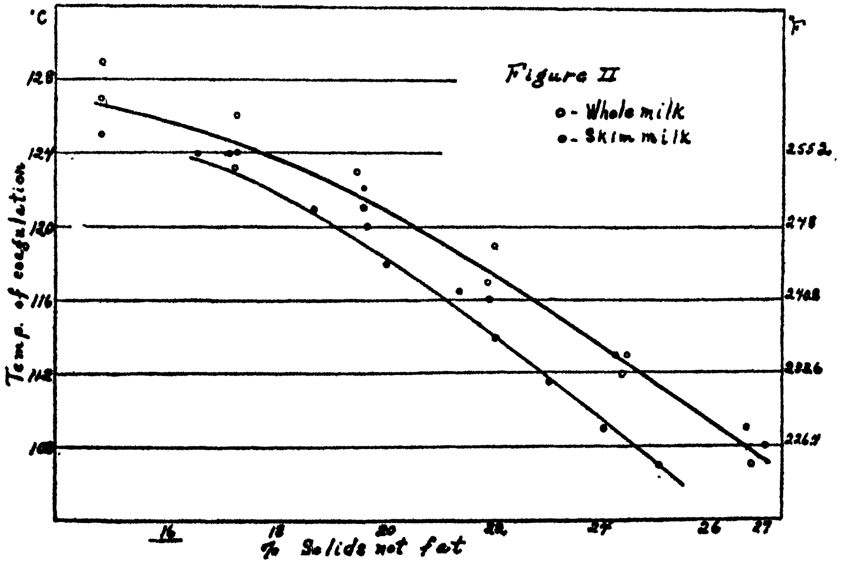

FIG. 2. RELATIONSHIP OF TEMPERATURE OF COAGULATION TO VARIOUS CONCENTRATIONS OF EVAPORATED SKIM MILK AND EVAPORATED WHOLE MILK

Figure 2 indicates that the change of coagulation temperature for changes of concentration of evaporated skim and whole milks is somewhat greater for evaporated skim milk than for evaporated whole milk.

The variation in the quality of the herd milk used from day to day as regards coagulation temperature is small. Any change in the percentage of solids not fat, not exceeding 0.3 per cent, causes a change in the coagulating temperature which is entirely within the range of error in sterilization.

Whether or not milk of inferior grade will have the same relationship of concentration and temperature of coagulation as fresh milk of good quality was ascertained by determination of the relation of the time to the coagulation temperatures of a milk that had been held at about 18°C. for twenty-four hours. This milk showed a decided drop in the temperature of coagulation.

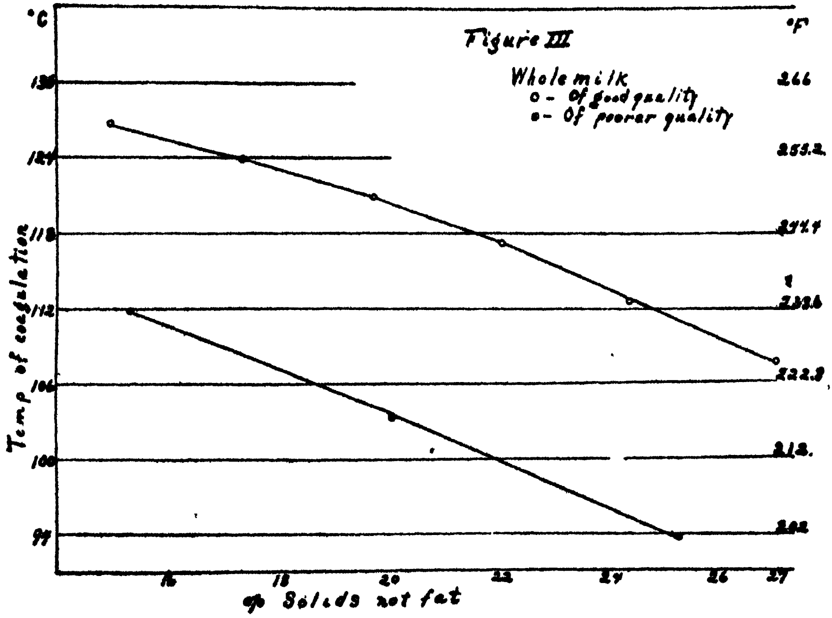

FIG. 3. RELATIONSHIP OF TIME AND TEMPERATURE OF COAGULATION IN MILK OF INFERIOR GRADE AND A MILK OF GOOD QUALITY

Figure 3 shows the relationship of time and temperature of coagulation of such a milk.

In the case of milk of inferior quality there is a decidedly lower coagulating temperature, but the relationship of concentration and temperature seems to be the same as for the milk of good quality.

The change in the inferior milk was undoubtedly caused largely by acid-forming bacteria. Whether or not this relationship will hold for any other type of flora is an open question. Some of the results obtained at this laboratory seem to show that there may be variations in the type of change caused by various flora.

TIME-TEMPERATURE RELATIONS IN STERILIZATIONS

No definite time and temperature of sterilization can be specified as giving the best results. These two factors must be adjusted to the quality of the milk on hand.

While it was the purpose of this experiment to find the relationship that exists between the time of sterilization and the temperature of coagulation, the authors have realized that the milk under examination is superior in quality to the milks received at most factories, and therefore have tried to ascertain whether the relations that hold for good milk will also hold for milk of inferior grade.

TABLE 1

Temperatures of coagulation of evaporated milk (18 per cent solids-not-fat) for various time periods

TIME	TEMPERATURE OF COAGULATION	
minutes	°C.	°F.
10	131	267.8
12	128	262.4
20	123	253.4
30	119	246.2
45	116	240.8
60	114.5	238.0

A sample of milk containing 18 per cent solids not fat was prepared and the temperatures of coagulation were determined for the various time periods.

Table 1 gives the results obtained with a fresh sample of evaporated milk.

Inasmuch as the temperatures usually employed for sterilization in factories are considerably lower than those used in this experiment, it might be possible that the relationships shown in the table above will not hold for milks of poorer grade. In order to determine this a fresh sample was kept at a low temperature until it showed a decided drop in its coagulation temperature.

A sample of evaporated milk was prepared containing 18 per cent solids not fat, and the temperatures of coagulation for the various periods of time were determined as in the former experiment. The results are seen in table 2.

TABLE 2

Temperatures of coagulation of a sample of milk which had been held for seven days at a temperature of 7° to 10°C.

TIME	TEMPERATURE OF COAGULATION	
minutes	°*C.*	°*F.*
15	116	240.8
30	110	230
45	107	224.6

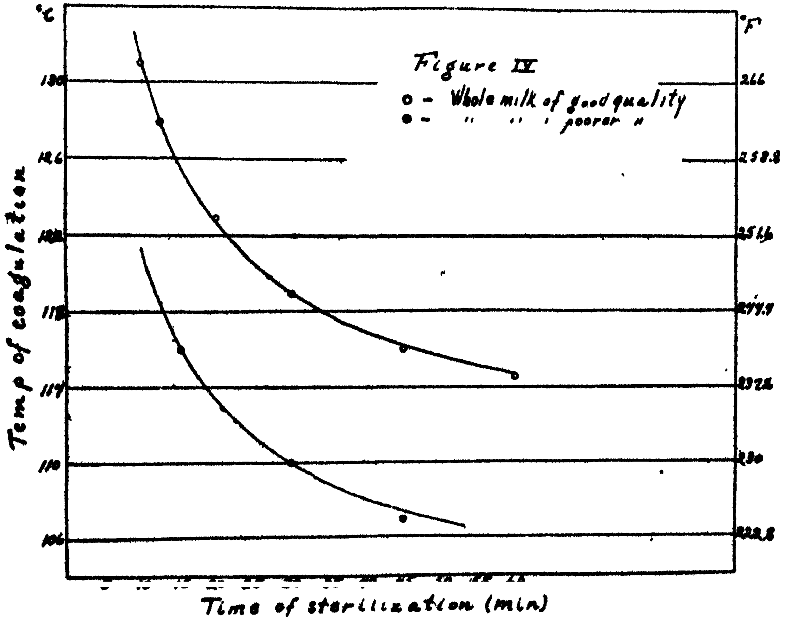

FIG. 4. RELATION BETWEEN TIMES AND TEMPERATURE OF COAGULATION IN TWO GRADES OF MILK FROM THE SAME HERD, AFTER EVAPORATION

The relations are more clearly brought out in figure 4.

The data seem to indicate that there is no sharp break in the relationship of time to temperature.

The relation of the variations in temperature of sterilization to those in time of sterilization approaches very closely a logarithmic nature. How closely this relation holds for the experiments recorded is shown in figure 5, where the logarithm of the total change in temperature from the temperature of coagulation at sixty minutes is plotted against the time in minutes.

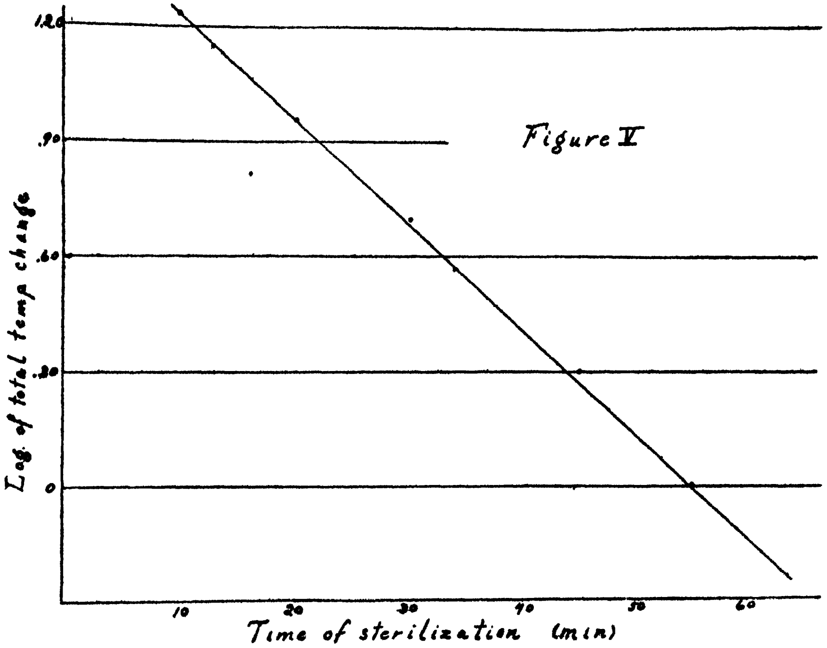

FIG. 5. SHOWING THE LOGARITHMIC NATURE OF THE RELATIONS SHOWN IN FIGURE 4

The data presented show that if the coagulating temperature of an evaporated milk, of approximately 18 per cent solids not fat, for a certain time period is known, we can predict approximately the temperature of coagulation for any other period of time; or vice versa, the time period required for any other temperature. For convenience a table such as the one given below might be of value, and it is perhaps better suited to practical use than a formula would be. Table 3 indicates the degrees that must be subtracted from the coagulating temperature (y) of any evaporated milk containing approximately 18 per cent solids not fat, for a ten-minute period, at each successive five-minute period.

If the coagulation temperature of an evaporated milk for a ten-minute period is found to be 130°C., the coagulation temperature for a thirty-minute period will be $y-12$ or 118°C.

For this same milk, suppose the coagulating time is required for a temperature of 120°C. The difference between this temperature and the coagulating temperature at ten minutes is 10°; or the coagulation temperature is $y-10$. The corresponding time will be twenty-four minutes. Again, if a milk just coagulates at 119°C. in thirty minutes, the temperature of coagulation for a forty-five minute period will be $(y-15)-(y-12)$ or 3°C. less than the coagulating temperature for thirty minutes, or 116°C.

TABLE 3

Variation in coagulating temperature for each time period in a series at five-minute intervals

TIME	TEMPERATURE OF COAGULATION	
minutes	°*C.*	°*F.*
10	y	y
15	$y-5$	$y-9$
20	$y-8$	$y-14.4$
25	$y-10.5$	$y-19$
30	$y-12$	$y-21.6$
35	$y-13$	$y-23.4$
40	$y-14$	$y-25.2$
45	$y-15$	$y-27$
50	$y-15.5$	$y-28$
55	$y-16$	$y-28.8$
60	$y-16.5$	$y-29.7$
75	$y-17$	$y-30.6$

Knowing that this milk coagulates at 119°C. in thirty minutes, one can ascertain the time required for a temperature of 123°C. as follows. The coagulation temperature for thirty minutes is 119°C., or is represented by $y-12$. The temperature 123°C. is 4° greater then the temperature for which the time is known, and will be represented by $y-8$. The time corresponding to $y-8$ as coagulating temperature, is twenty minutes.

In order to avoid confusion in calculations it is well to keep always in mind that the higher the temperature the shorter the time, and vice versa.

SUMMARY

In order to make the results obtained upon various milks comparable with respect to time and temperature of coagulation it is necessary to calculate all concentrations upon the basis of the proportion of solids not fat to the total weight minus the weight of the fat. While calculations of solids upon the basis of total solids (including fat) will hold for all milks with approximately the same fat content, any variations in the percentage of fat will introduce error into the data of true concentration of proteins and consequently will introduce error into coagulation data. A calculation of results upon the basis suggested will give a true basis for the comparison of the stability of evaporated milks toward heat, and make possible a comparison of milks from day to day, as well as of skim and whole milks, whatever may be their fat content. The presence of a high fat content in a milk will raise its coagulating temperature slightly over that of skim milk from the same sample, due in all probability to the absorption of heat by the fat present in the whole milk. It would seem therefore that in studying the mechanism of coagulation the most reliable results would be obtained with skim milk.

The relation of the coagulation temperature to the concentration of evaporated milk, between the concentrations of 16 and 26 per cent, has been determined. The greater the concentration the greater the variation between skim and whole evaporated milk from the same sample.

In the region of concentration which is of most interest (18 to 20 per cent) the change of coagulation temperature for every 1 per cent change in concentration is approximately 1.5°C. In higher concentrations the change is slightly more.

The relation between concentration and coagulation temperature in a milk of poor quality seems to parallel that in a milk of good quality.

The relation of the temperature of coagulation to the time of coagulation has been determined between ten and sixty minutes and found to approximate very closely a logarithmic relation, with respect to time. Knowing the time and temperature of coagulation of a milk of certain concentration, therefore, one can approximate the temperature of coagulation for any other period of time. The same relationship between time and temperature seems to hold for milks of poorer grade.

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THE VALUE OF MILK INSPECTION FOR A SMALL CITY

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The value of milk inspection for a small city is very conclusively shown in the results of a series of surveys conducted in the city of LaFayette, Indiana, over a period of nearly two years.

In October 1921, a survey was made to determine the quality of the milk sold. It was found that there were 37 distributors of which 34 were also producers, and all but 2 were selling milk in the raw state. During the month at different intervals six samples of milk were collected from each distributor and the bacterial count determined according to Standard Methods of Milk Analysis 1921, the per cent of milk fat, visible dirt and total solids. The per cent milk fat in all cases was well above the State standard of 3.25 per cent and judging from the total solids no water adulteration was found. Sixty-six per cent of the samples collected contained more than 1,000,000 organisms per cubic centimeter the highest count obtained being 7,000,000 and the lowest 270,000 organisms per cubic centimeter. The bacterial count had little or no time to increase for the samples were taken from the wagons as they made their early morning delivery and in all cases immediately placed on ice and plated within two hours. The amount of visible dirt found on sediment discs showed only two distributors and one of those was using a clarifier had pads equal to a No. 1 pad, the remaining grading downward. Public sentiment was aroused thru a series of meetings and thru the local medical association, causing the city administration to act.

Early in 1922 a veterinarian was appointed milk inspector by the city administration, to devote one fourth his time in endeavoring to have the producers tuberculin test their cattle and to instruct them in better methods of handling milk. In a survey which was made the latter part of March following the same procedure as the previous survey, it was shown that 38 per cent of the samples collected had more than a million organisms per cubic centimeter and 20 per cent with 50,000 or less, and 80 per cent of the sediment discs graded out no. 1. The highest count shown in March was 4,190,000 and the lowest 10,000. Owing to the pressure of his professional work no inspection or instructional work was carried on from March to June, and with warmer weather conditions the survey conducted in June shows an increase in bacterial content of the milk. Forty-two per cent of the samples collected had more than 1,000,000 and only 5 per cent with a count of less than 100,000.

In October, 1922, the milk inspector resigned and another veterinarian appointed under the same conditions. The following program was outlined:

1. That samples were to be collected at different intervals during the month from the majority of distributors, especially those who continued to give high counts.

2. Each distributor was to be informed personally as to the condition of his milk and methods to be used for bettering his milk.

3. That results be published in the local paper.

4. To have all the milk that is sold in a raw state from tuberculin tested cattle.

5. That a series of meetings to be held with the distributors to discuss means of bettering the milk supply. The survey made in November after one months work of the inspector showed 4 per cent of the samples collected to be over 1,000,000 and 72 per cent under 100,000. The inspector had particularly instructed them in the means of removing visible dirt and means of sterilizing their utensils. Similar surveys were conducted during the months of December to May, 1923, of which the results are explained in the following table. In the case of October, 1921, March and June, 1922, samples were obtained from all the distributors. In the succeeding surveys a majority of the distributors' milk was analyzed. The inspector endeavored to obtain samples from those distributors whose milk was of the poorest quality in previous surveys.

TABLE 1

The percentage distribution of samples collected from distributors in regards to bacterial content

COUNT	OCTOBER, 1921	MARCH, 1922	JUNE, 1922	NOVEMBER, 1922	DECEMBER, 1922	JANUARY, 1923	FEBRUARY, 1923	MARCH, 1923	APRIL, 1923	MAY, 1923
5,000–10,000		5		4		30 6	55	7	20	
11,000–25,000		5	5	28	17	12.6	7	14	30	8
26,000–50,000		10		24	10	12.6	23	14		30
51,000–100,000				16	10	19.0	15	28		8
101,000–250,000	9	32	5	16	50	6.3		7		8
251,000–500,000	9	5	27	8	13	6.3		14	20	16
501,000–1,000,000	16	5	21			6.3		14	30	30
1,001,000–over	66	38	42	4						

SUMMARY

That milk inspection service in small cities is practical and by expending a comparatively small amount of money, in the case of the city of LaFayette $1000 per year covered all expenses, a marked improvement upon the quality of milk can be obtained. The results quoted were accomplished by a veterinarian devoting one-fourth of his time. Devoting of more time by the inspector and the conduction of more surveys would undoubtedly yield greater improvement.

STUDIES IN THE GROWTH AND NUTRITION OF DAIRY CALVES

VIII. RAISING DAIRY HEIFERS BY MEANS OF THE SELF-FEEDER

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The self-feeder is now recognized as a valuable adjunct in the feeding of hogs and also to some extent in fattening beef cattle. Its use with dairy cattle is still in the experimental stage, however, and the project reported here is supplementary to the work outlined in paper VII of this series.

RÉSUMÉ OF PREVIOUS WORK

Part of the work on the use of self-feeders and problems intimately connected with their use has already been reviewed in paper VII of this series but a few additional references may be given here.

Among the few references obtainable it is found that both Cook (59) and Nevens (62) reported good results where a grain mixture was provided in a self-feeder for calves. On the other hand, Hunt (61) found that cows in milk, when allowed access to a self-feeder, consumed so much grain that milk production was very uneconomical.

A report has already been given of the preference of young calves for whole grains and Hanly (60) obtained similar results, while Woll and Voorhies (63) found a slight advantage in feeding ground grain but the difference was not sufficient to pay for the grinding.

EXPERIMENTAL WORK

The work outlined here was undertaken with the view of ascertaining the possibility of raising dairy heifer calves from birth to the age of first freshening with the aid of the self-feeder.

The feeds used were very similar to those used in the earlier work reported in paper VII of this series, with the exception that gluten feed and hominy meal, which had proved to be unpalatable, were excluded.

Three purebred heifer calves were used. All were in good growthy condition when put on the self-feeder at an average age of 27 days. Information concerning them is given in table 45 and where necessary it is calculated to October 5, 1919, the day on which the trial started.

TABLE 45

Animals used

	CALF 487	CALF 491	CALF 493	AVERAGE
Breed	Jersey	Ayrshire	Holstein	
Birth weight *pounds*	64	60	80	68
Age, *days*	43	20	19	27

TABLE 46

Previous feed

	CALF 487	CALF 491	CALF 493	TOTAL	AVERAGE
Sucking, *days*	1	6	5	12	4
Whole milk, *pounds*	359	103	103	565	188
Pasture, *hours*	328	104	104	536	179

From the time of removal from their dams, until the beginning of the experiment, the calves had been receiving whole milk and were on pasture a few hours daily. In addition, calf 487 had also had a little hay and grain before the start of the trial.

All feed records were kept by 30-day periods and at the end of each period the animals were weighed on each of three successive days and the average of the three weighings was considered to be the weight of the animals at the end of the period. The height at withers, depth of chest and width at hooks was also determined for each animal.

The original intention was to carry the animals to the age of first freshening but as difficulties apparently arose regarding the breeding of the heifers, the trial had to be discontinued at the end of the twenty-second period.

At the beginning of the experiment the animals were all receiving whole milk, hand fed, and had before them at all times alfalfa hay and salt. The self-feeder kept in their pen contained the following concentrates:

Shelled corn
Cracked corn
Whole oats
Ground oats
Wheat bran
Linseed oil meal O. P.

The calves were turned out daily for exercise and water and during the first 27 days they were on pasture for 8 hours daily. During the winter they were exercised and watered daily in the dry lot. When the pasture was ready in spring the heifers were turned out. The three animals were on a pasture of 2.09 acres and for shelter they had an open shed in which the self-feeder was kept.

The feeding of milk and alfalfa was discontinued during the eighth period and from the beginning of the ninth period to the end of the trial the animals were continuously on pasture but had access to the self-feeder at all times up to the end of period XVIII. Periods XV to XX were in winter and during that time alfalfa hay was again fed and silage was also allowed. In this winter period, however, the heifers also obtained some feed from the pasture. In the last two periods pasture alone was allowed.

DISCUSSION OF RESULTS

The feed records were kept by 30-day periods but in order to study the early actions of the calves the record for the first 30 days was kept in 10-day periods. In considering this first period it is found that the calves took readily to the whole corn and whole oats and consumed considerably less of the ground feeds. They consumed a relatively liberal amount of wheat bran but only about half as much oil meal as whole corn or whole oats. Their consumption of grain was greater during the first 10 days than was their consumption of alfalfa hay, but during the second 10-day period they decreased their grain consumption, particularly the oil meal and bran and increased their hay consumption. Evidently therefore, they took relatively too much grain during the first 10 days but immediately proceeded to correct it as their hay consumption exceeded their grain consumption for the 30-day period.

TABLE 47

Feed consumption during period I

	SUB-PERIOD			TOTAL	AVERAGE PER HEIFER
	i	ii	iii		
	pounds	*pounds*	*pounds*	*pounds*	*pounds*
Whole milk	263	309	312	884	295
Whole corn	3.2	5.6	1.9	10.7	3.6
Cracked corn	0.0	0.9	0.9	1.8	0.6
Whole oats	2.4	2.8	5.6	10.8	3.6
Ground oats	1.2	0.5	3.2	4.9	1.6
Wheat bran	4.0	1.9	1.4	7.3	2.4
Oil meal	3.2	0.0	1.4	4.6	1.5
Alfalfa hay	4.8	15.8	27.3	47.9	16.0

TABLE 48

Individual milk consumption

PERIOD NUMBER	CALF 487		CALF 491		CALF 493		TOTAL		AVERAGE	
	Whole milk	Skim milk	Whole milk	Skim milk	Whole milk	Skim milk	Whole milk	Skim milk	Whole milk	Skim milk
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
I	294		262		328		884		295	
II	302		302		392		996		332	
III	315		212	138	256	161	783	299	261	100
IV	315		180	180	210	210	705	390	235	130
V	315		180	180	210	210	705	390	235	130
VI	296	15	162	192	189	225	647	432	216	144
VII	120	199		260		336	120	795	40	265
VIII		90				90		180		60
Total	1957	304	1298	950	1585	1232	4840	2486	1613	829

The milk feeding was at no time heavy, the animals being fed limited amounts twice daily, as it was felt best to allow the calves to choose their own feeds as much as possible. The fact that the calves did not lack for feed and developed well even on limited amounts of milk is shown by the live weight gains.

In considering the total amounts of feed consumed it is found that cracked corn came first among the concentrates and was followed closely by whole corn, while whole oats was considerably behind, amounting to only about one-third of the whole corn. The amount of oil meal consumed was only about half that of whole oats while wheat bran was considerably lower and the ground oats consumed was but a very small amount. Roughly, there was one and a half times as much whole corn consumed as of all other concentrates combined, with the exception of cracked corn which was consumed in even larger amounts than the whole corn.

The total consumption of the various grains is perhaps not of as great interest as the changes which take place in the relative amounts of them consumed at various stages in the trial. During the first six periods when the amounts of whole milk fed exceeded the skim milk there was a steady increase in the amount of whole corn consumed while the cracked was consumed in insignificant amounts. The same holds true for both whole and ground oats, in fact the calves appear to have tried them at first and then decreased their consumption of them. The wheat bran also formed an insignificant part of the grain ration during this time, though the amount of oil meal used increased considerably with the exception of a very severe drop in the fifth period.

In the seventh period the skim milk fed exceeded the whole milk and in the eighth period skim milk alone was used for a time. The consumption of the whole corn reached its peak in the seventh period, probably owing to its use for the replacements of the butterfat removed from the ration, but in the eighth period it dropped. This drop in whole corn consumption was accompanied by an enormous increase in the amount of whole oats used. The bran consumption increased greatly during the seventh and eighth periods and that of oil meal also went up, while the amounts of cracked corn and ground oats consumed remained low.

The heifers were turned to pasture at the beginning of the ninth period and from there to the end of the fourteenth period they were under summer conditions and receiving no milk. Throughout this time the consumption of whole corn decreased and that of cracked corn increased. The consumption of oats in any form was low until the last 30-day period of this section when the amount of whole oats consumed was large. The consumption of bran was somewhat irregular though with a tendency to increase when compared with the previous production. The oil meal consumption dropped to zero during the first thirty days on pasture and during summer was never high.

TABLE 49

Total feed consumption by 30-day periods

PERIOD NUMBER	WHOLE MILK	SKIM MILK	WHOLE CORN	CRACKED CORN	WHOLE OATS	GROUND OATS	WHEAT BRAN	OIL MEAL	ALFALFA HAY	CORN SILAGE	SALT
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
I	884		11	2	11	5	7	5	48		0.31
II	996		24	6	44	15	1	2	133		0.23
III	783	299	208	2	0	25	0	27	122		0.24
IV	705	390	308	0	6	13	0	99	153		0.09
V	705	390	466	0	9	11	2	7	129		0.06
VI	647	433	577	5	1	6	2	96	144		0.19
VII	120	795	651	8	1	7	43	111	149		0.05
VIII		180	538	6	180	7	52	118	157		0.60
IX			490	327	16	0	4	0			1.44
X			511	438	26	19	77	46			1.05
XI			343	612	0	0	33	17			1.04
XII			508	329	23	9	79	51			1.03
XIII			448	685	51	24	15	80			1.04
XIV			252	732	188	0	73	59			1.05
XV			31	835	172	33	0	91	242	674	0.84
XVI			44	927	480	23	14	31	165	106	0.70
XVII			1	913	399	0	0	21	199	192	0.65
XVIII			412	584	235	0	16	13	254	219	0.72
XIX									537	892	0.83
XX									142	1425	1.20
XXI											1.16
XXII											1.01
Total.....	4840	2487	5823	6411	1842	197	418	874	2574	3508	15.58

During the fifteenth to eighteenth periods corn silage and alfalfa hay were given at free will and during this time the whole corn consumption decreased and that of cracked corn increased until the last 30 days when there was a radical change in the opposite direction. The consumption of whole oats increased with the exception of the last period. Ground oats and bran were consumed in but small amounts and the consumption of oil meal though increased in the first 30 days declined towards the end.

TABLE 50

Consumption of whole and ground grains

PERIOD NUMBER	WHOLE GRAIN			GROUND GRAIN			AMOUNT OF WHOLE GRAIN PER POUND OF GROUND GRAIN
	Corn	Oats	Total	Corn	Oats	Total	
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
I	11	11	22	2	5	7	3.1
II	24	44	68	6	15	21	3.2
III	208	0	208	2	25	27	9.6
IV	308	6	314	0	13	13	24.2
V	466	9	475	0	11	11	43.2
VI	577	1	578	5	6	11	52.5
VII	651	1	652	8	7	15	43.5
VIII	538	180	718	6	7	13	55.2
IX	490	16	506	327	0	327	1.5
X	511	26	537	438	19	457	1.2
XI	343	0	343	612	0	612	0.6
XII	508	23	531	329	9	338	1.2
XIII	448	51	499	685	24	709	0.7
XIV	252	188	440	732	0	732	0.6
XV	31	172	203	835	33	868	0.2
XVI	44	480	524	927	23	950	0.6
XVII	1	399	400	913	0	913	0.4
XVIII	412	235	647	584	0	584	1.1

From the time the calves were put on the trial until they went to pasture, 210 days later, they had free access to alfalfa hay and the consumption of this increased fairly readily. During the following summer they had no roughage but pasture but at the approach of winter they were given corn silage and alfalfa hay. These roughages were fed for 6 months and during the first 4, grain was also being given. During the first period of feeding the silage was consumed in fair amounts but for the next three little of it was consumed as it frequently froze before the heifers would consume it. The consumption of hay remained fairly constant. For the two periods after the grain was removed the silage consumption increased greatly and there was an increase in hay consumption for 1 month but in the last month it was inhibited probably by the greater silage consumption and the freshening of the pasture. In the last two months of the trial the animals received pasture only.

The salt consumption increased irregularly from the start of the trial until the calves were weaned and put to pasture. At this stage there was a great increase in salt consumption and this was fairly well maintained until the introduction of alfalfa and silage at the beginning of winter when the salt consumption again fell and remained low until after the grain had been removed and the heifers were beginning to get fresh pasture again. At this time it again rose and remained so until the trial ended.

In comparing the amounts of whole corn and oats consumed with the amount of the ground grains utilized, it is found that from the beginning of the trial until the end of the eighth period, when the calves were weaned and put to pasture, that the amount of whole grain increased from 3.1 pounds per pound of ground grain consumed in the first period to 55.2 pounds per pound of ground grain in the eighth period. During this time therefore the preference of the calves was for whole grains. From then on however, whether the calves were on pasture or on alfalfa and corn silage, there was no such marked preference for the whole grains. Sometimes they consumed more whole than ground grains and at other times considerably less.

Taking the two main groupings it is found that while the calves were receiving milk, grain and hay, they consumed 25.7 pounds of whole corn and oats for each pound of the ground grains, while the ratio was only 0.7 pound of the whole grains per pound of ground grains when the heifers were getting grain and were on pasture or being fed silage and alfalfa. At no time however, were ground oats consumed in appreciable amounts and it was only toward the end that whole oats were eaten in considerable quantities.

TABLE 51

Average live weights and body measurements

TIME	LIVE WEIGHT	HEIGHT	DEPTH	WIDTH
	pounds	*inches*	*inches*	*inches*
Birth	68			
Start of trial	80	28.1	11.3	6.2
End of period:				
I	113	29.6	12.5	7.4
II	155	31.6	14.0	8.2
III	220	34.3	15.6	9.3
IV	278	35.9	16.4	10.5
V	321	37.8	17.6	11.3
VI	398	39.4	18.7	12.1
VII	469	41.0	19.9	13.3
VIII	515	42.1	20.7	13.7
IX	568	42.9	21.5	14.4
X	622	43.7	22.2	15.2
XI	677	44.5	22.6	15.6
XII	733	45.2	23.0	16.0
XIII	787	46.0	23.8	16.4
XIV	842	46.8	24.2	17.2
XV	854	47.6	24.6	17.6
XVI	905	48.0	25.4	17.9
XVII	954	48.4	25.7	18.3
XVIII	984	48.8	25.7	18.7
XIX	973	49.1	25.7	19.1
XX	990	49.5	26.1	19.1
XXI	991	49.5	26.1	19.1
XXII	972	49.5	26.5	19.1

TABLE 52

Percentage increase in live weight and body measurements

AGE	HEIFERS FED NORMALLY				HEIFERS ON SELF-FEEDER			
	Live weight	Height	Depth	Width	Live weight	Height	Depth	Width
months	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
6	309	34	57	67	372	35	56	82
12	731	54	92	118	896	58	100	155
18	988	64	112	146	1303	72	127	195
23	1171	68	121	164	1622	76	135	208

The average live weights of the heifers from the time of birth to the finish of the trial are given and the body measurements from the beginning of the trial. The calves used in this work were practically 1 month of age when the work was started and in order to get an idea of their relative rates of growth, they are compared with calves fed under normal conditions. This comparison is made on the percentage increase in live weight from birth and body measurements from one month of age. This method was used in paper III of this series and the averages for the normally fed animals used in the work reported in that paper are used as a basis of comparison for the animals discussed here.

The calves used in the self-feeder trial were slightly below normal in live weight and body measurements at the start but they gained rapidly and at the end of the twenty-second period of the trial, when the self-fed heifers were 23 months of age they showed greater development in weight and all body measurements except width than the normally fed heifers did at the age of freshening, namely, 29 months. Their growth in weight and body measurements at the first of the trial greatly exceeded that for the normally fed heifers.

TABLE 53

Relative increase in growth of self-fed heifers as compared with normally grown heifers

AGE	LIVE WEIGHT	HEIGHT	DEPTH	WIDTH
months	*per cent*	*per cent*	*per cent*	*per cent*
6	101	103	98	122
12	123	107	109	131
18	131	113	113	134
23	130	112	111	127

For further comparison the relative increases in live weight and body measurements of the self-fed heifers are compared with the same increases for the normally fed animals by 6 months periods. In other words, the average percentage increase in live weight of the self-fed heifers during their first 6 months is expressed as a percentage of the average percentage live weight increase during their first period of 6 months for the normally fed animals.

On examining the data by this method it is found that on the whole the self-fed heifers increased relatively more rapidly in live weight than they did in body measurements. This indicates in the best possible way the tendency for the self-fed heifers to

FIG. 1. HEIFER 487 AT 15 MONTHS OF AGE

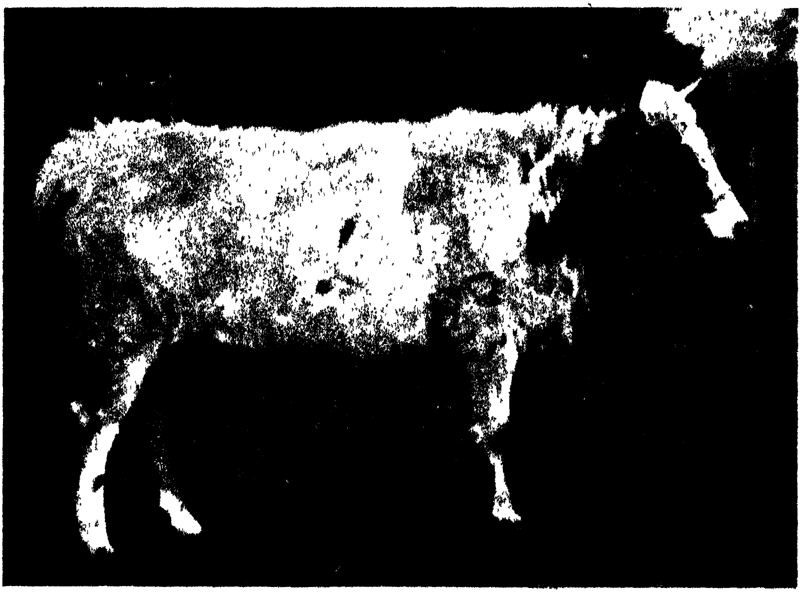

FIG. 2. HEIFER 491 AT 15 MONTHS OF AGE

lay on fat and get in higher condition than the normally fed animals.

When the body measurements alone are considered it is found that the greatest relative increase is in the width at the hooks and of the three measurements taken, this is the one most easily affected by condition. The height at withers and the depth of chest do not seem to be affected to such a great degree. All the body measurements were above normal, due to some extent to extra fleshing at the hooks, over the withers, and on the floor of the chest, but also undoubtedly to some extent due to increased skeletal growth.

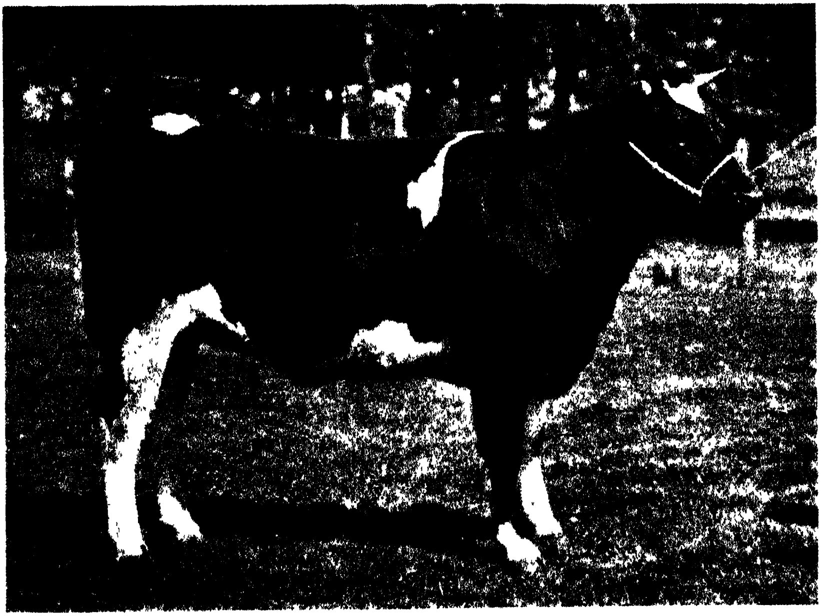

FIG. 3. HEIFER 493 AT 15 MONTHS OF AGE

It should be noted that from 18 to 23 months of age there was a falling off in the relative increases in the live weights and body measurements of the self-fed heifers. This was due to the fact that during the latter part of this period the heifers were on pasture only and lost in live weight and the outward evidences of condition.

The feed cost of growing the self-feeders has been determined with the same feed costs as were used in paper IV of this series in determining the cost of growing heifers fed normally. The costs of growing the normal heifers to 24 months of age are given as they were originally calculated on that basis while the feed cost for the self-fed heifers is given to 23 months—the age of the heifers when the trial finished.

The feed costs of growing the normal and self-fed heifers do not vary as widely as might be expected, up to 18 months of age, but from there to the age of 23 or 24 months there is a difference which needs explanation. In the first 6 months of life the calves, as would be expected, show practically the same individual feed costs, but in the two succeeding 6 months periods, the self-fed heifers ate relatively more grain per head and so at 18 months of age the total feed cost of growing the normal heifers was $73.51 and that for the self-fed heifers was $78.51 or $5 per head more. Up to this time the cost per pound of gain for the self-fed group was below normal, that for the normally fed heifers being 11.1 cents per pound and that for the self-fed animals 8.9 cents per pound. In paper IV of this series the heifers were divided into winter and summer groups, according to the time at which they were dropped. As the self-fed heifers were in the winter group it is well to state that the normal cost per pound of live weight gain up to 18 months of age was 11.4 cents for the winter group.

TABLE 54

Average feed cost of growing heifers

AGE	FEED COST BY 6-MONTH PERIODS		CUMULATIVE FEED COST		FEED COST PER POUND OF GAIN BY 6-MONTH PERIODS		CUMULATIVE FEED COST PER POUND OF GAIN	
	Normal	Self-fed	Normal	Self-fed	Normal	Self-fed	Normal	Self-fed
months	*dollars*	*dollars*	*dollars*	*dollars*	*cents*	*cents*	*cents*	*cents*
0–6	35.57	35.81	35.57	35.81	14.4	14.1	14.4	14.1
6–12	20.18	21.78	55.75	57.59	8.3	6.1	11.4	9.5
12–18	17.76	20.92	73.51	78.51	10.3	7.6	11.1	8.9
18–24	16.27		89.78		9.4		10.7	
18–23		8.72		87.23		48.4		9.6

From 18 to 24 months of age the feed cost for normally fed heifers was $16.26 while the feed cost for the self-fed heifers was $8.72. This marked difference in favor of the self-fed animals is due in great part to fact that in the latter part of this stage the self-fed animals were on pasture alone, while the other animals had been receiving grain. The normally fed winter heifers during the period of from 18 to 24 months of age had an average feed cost of $15.16.

From the age of 18 to 23 months the self-fed heifers showed little live weight gain, in fact at 23 months of age they weighed less than they did at 19 months of age. This is due to the fact that when grain was taken away from them completely and they were left to subsist on young grass alone, a considerable amount of shrink occurred and this had not been completely overcome at the end of the trial. Consequently, the feed cost per pound of gain during the last 5 months is exceptionally high. On the average the feed cost per pound of live weight gain from birth was 9.6 cents in the case of the self-fed heifers at 23 months of age and 10.7 cents per pound in the case of the normally grown heifers at 24 months of age.

TABLE 55

Breeding of heifers

HEIFER NUMBER	DATES OF BREEDING	DATE OF SUCCESSFUL BREEDING	FRESH	CALF		AGE AT FRESHENING
				Sex	Weight	
					pounds	*months*
487	12/10/20					
	1/ 2/21	1/2/21	9/28/21	F	41	25
491	1/ 2/21					
	1/23/21					
	3/ 3/21	3/3/21	12/ 9/21	M	75	27
493	2/26/21					
	4/ 5/21					
	7/ 6/21					
	8/ 7/21	8/7/21				32
Average.....	3					28

There is apparently some difference in the feed cost per hundred pounds of live weight gain between heifers fed in the ordinary method and those self-fed. This is true when they reach the age of about 2 years and the self-feeder would appear to have other advantages as the animals raised by this method need less attention when they have passed weaning age and grow heavier and larger.

In connection with the work with the heifers raised with the self-feeder a record was kept of the breeding of the animals and as was noted earlier the trial was discontinued owing to apparent difficulty in getting them bred.

The heifers, nos. 487 and 491, were settled during the trial but owing to their condition it was a difficult matter to tell, in the early stages, whether or not they were pregnant. Later on, on examination, per rectum, they proved to be in calf. They freshened at ages which are normal for the breeds to which they belong. The heifer 487 was a Jersey, freshening at 25 months of age, and no. 491, an Ayrshire, freshening at 27 months. Throughout the trial the Jersey heifer was in relatively lower condition than the Ayrshire. The Holstein heifer, no. 493, was in the highest condition throughout the trial. As yet she has not freshened but on examination, per rectum, has shown that she is going to freshen to the breeding of August 7, 1921. This means that she will freshen at 32 months of age—a rather advanced age for a heifer of her development.

The animals were of different breeds and this induces a factor beyond control, but there should not be much difference in the freshening ages of Ayrshires and Holsteins and it can readily be seen that there was much more difficulty in getting the Holstein settled and this is very probably due to the exceedingly high condition she was in. She was only bred successfully after she had been on pasture alone for some time and lost in condition.

SUMMARY

From this trial with a self-feeder in the raising of dairy heifers it is probable that the following suggestions may be made:

1. There is little difference in the feed cost of raising heifers to two years of age by the self-feeder method or by hand feeding where a liberal grain allowance is given.
2. The feed cost per pound of gain is lower with the self-fed heifers.
3. The heifers raised with the self-feeder will show the greater increases in live weights, height at withers, depth of chest and width.
4. The greatest relative increase will be in the live weight and though the skeletal measurements mentioned do show a true increase, this is further augmented by extra fleshing.
5. With self-fed heifers the extra conditioning may tend to delay breeding, or perhaps impair their breeding powers.
6. Ground oats and wheat bran are not palatable to heifers.
7. When the heifers are on a milk ration, whole corn is the grain consumed in greatest quantities; cracked corn and whole oats being used but little.
8. After weaning, and when under summer conditions, the consumption of cracked corn increased while that of whole corn decreased.
9. When the heifers were under winter conditions, after they were a year old, cracked corn and whole oats were apparently the most palatable grains.
10. Linseed oil meal was evidently a palatable supplement though the quantities of it consumed varied from time to time.
11. Salt was consumed regularly. The largest amounts were used when pasture was available.

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A STUDY IN HERD EXPANSION

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Recently we have had the privilege of studying records of a herd of dairy cattle that was established in 1896, twenty-seven years ago. To found the herd 14 nice cows were purchased and ever since then the best heifer calves have been retained to enlarge and improve the herd.

Like every other herd, this one has been visited by its quota of abortions, tuberculosis, accidents and defectives, but it has received unusually good attention, care, feed and stabling. We believe its rate of expansion, or growth, will prove interesting to breeders of cattle. A review of this herd is as follows:

1896—Herd founded with 14 cows.

1912—The herd in 1912 contained 29 female descendents of the 14 cows. Eleven of the 14 foundation cows failed to produce enough offspring, particularly heifers, to breed on and disappeared from the herd in the sixteen years, while 3 prolific cows are responsible for the herd growth.

1922—The herd in 1922 contained 37 females, all descendants of the 29 females of 1912.

During the twenty-six years an effort has been made to enlarge and improve the herd by retaining the best heifers, the bull calves being sold. The herd growth was not rapid, having been held in check by such difficulties as deaths, accidents, tuberculosis, infertility, defects that caused the culling out of individuals such as sway backs, and loss of quarters of udders. These difficulties are met by all breeders of livestock, but this herd has been fortunate as no wholesale disaster has ever hit this herd, such as sometimes happens.

During the first sixteen years the females worthy of retention slightly more than doubled the size of the herd, while during the next ten years the herd increased from 29 to 37 females, an increase of 8 females. During twenty-six years the herd increased from 14 foundation cows to a herd of 37 females. Twenty-six of the 37 trace to one extra prolific cow that was among the 14 "originals."

A STUDY OF HEIFERS PRODUCED FROM 37 COWS DURING A FIVE YEAR PERIOD

A study of this herd covering five years, with 37 cows, shows that they produced during that period 151 calves, of which 61 were heifers. Therefore, 30.2 cows calved each year, with 6.8 cows barren each year, a percentage of 23 per cent barren. That is 30.2 cows calved every year, and 6.8 failed to calve, but they did calve irregularly. There were no infertile cows in the herd.

Female progeny of 37 cows in five years

37 cows produced 151 calves in five years (90 bulls and 61 heifers)
Average of 30.2 calves annually from 37 cows
Per cent of barren cows, 23 per cent

Growth of 61 heifer calves

61 heifer calves
    7 aborted dead or weak and killed
54 living heifers at birth
    11 weak heifers vealed under six months old
43 strong six months old heifers
    3 good heifers sold to other breeders
    4 good heifers became defective
    4 good heifers died
32 good two year old cows
    4 reacted
    5 had accidents
23 good three-year-old cows

This herd of 37 cows produced in five years 151 calves, of which 90 were bulls and 61 heifers. Seven of the heifers were aborted and 11 were weak or so inferior as to be vealed before they were six months old, leaving 43 good strong heifers, or an average of 1.13 good strong six months old heifers per cow in five years.

While they were under two old years the owner of the herd sold 3 heifers to other breeders of dairy cattle and sold to butcher 4 heifers that had become inferior, aborted or had bloated and been stuck, which always deteriorates an animal, or that had become out of condition. Four heifers died under two years old.

Some breeders try to rear every living heifer that is born. There were 54 living heifers born in this herd in the five years, 7 of the 61 were aborted dead. Figuring on the basis of the 54 living heifers, 32 grew into good two-year-old cows, a ratio of 54 heifers to 32 cows, or 59 per cent. But we prefer to figure on the basis of the 43 good strong heifers. These 43 strong six-month-old heifers grew into 32 good two-year-old milk cows, a percentage of 74.5 per cent, or about 7 good young cows raised from 10 good heifer calves. But 4 of these young cows reacted and 5 had accidents, such as injury to udder, abortions, etc., to befall them and were culled out. This left this breeder 23 good three-year-old cows from his crop of 54 living heifer calves, or from his crop of 43 good six-months-old heifers.

THE ACIDITY PHASE OF THE ICE CREAM MIX[1]

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The success of ice cream making is wholly dependent upon the preparation and handling of the ice cream mix. Recent experiments have pointed out the desirability of aging the mix for twenty-four to seventy-two hours (1). The primary object of aging is to increase the viscosity of the mix which aids considerably during the process of freezing in as much as it favors the incorporation of air into the ice cream and less time is consumed in whipping up the mix to the desired overrun than in the case of a fresh mix (2). The viscosity of the aged ice cream mix is influenced by several factors. What rôle does acidity play in the ice cream mix?

At the time this experiment was inaugurated no analytical work dealing with the acidity phase of the ice cream mix was on record with the exception of the following statements made in publications on ice cream making.

> The acidity of the cream has no effect on the swell of the ice cream produced, until it reaches such a point as to cause the cream to become brittle, when a lessened yield will result. Either natural, or added commercial lactic acid seems to improve the body and texture slightly. A cream containing 0.50 per cent or even 0.60 per cent acid will make a good looking and good feeling ice cream and except for the sour taste, will be as satisfactory an article as could be desired (3).
>
> The development of a small amount of lactic acid in the ice cream mix may have a pronounced effect in increasing the overrun. The development of a large amount of acid does not seem to materially increase the overrun and of course, it may be detrimental to the flavor of ice cream (4).

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[1] A part of the "Study of the principles of ice cream making" This material is based on a thesis presented to the faculty of the Graduate School of the University of Nebraska by Benjamin I. Masurovsky in the degree of Master of Science in Dairy Husbandry.

[2] Adams Fund Project 105, under direction of H. P. Davis, University of Nebraska, Agricultural Experiment Station, Lincoln, Nebraska.

The acidity is an important factor in obtaining the most desirable flavor and texture in the finished product and in controlling the overrun. An acidity of between 0.25 and 0.30 per cent is considered as giving best results. The presence of too much acid may cause the mix to curdle, particularly where the same is pasteurized. The acidity may be immediately increased by adding cultured buttermilk when compounding the mix. This will insure a good sharp flavor; permit of pastuerization thus insuring a low bacteria count, and make it possible to produce a mix of constant and ample viscosity. Possibly the aging period in the case of mix treated in this manner can be shortened or dispensed with. This is a phase of the ice cream industry that is in its infancy, and it opens possibilities for very interesting studies (5).

With this scant information regarding the acidity phase of the ice cream mix and its importance in ice cream making it was difficult to start consistent work pertaining to this problem. The experiments reported in this manuscript give the results obtained in preliminary work dealing with the titratable acidity, H-ion concentration, and buffer action of the ice cream mix and the findings throw some light on this subject which will, doubtless, facilitate the organization of a systematic series of experiments on the relation of acidity to the various essential factors involved in the manufacturing of commercial ice cream.

EQUIPMENT

1. Fifty gallon vat pasteurizer "Wizard" provided with a rotary coil. Creamery Package Co.
2. "Progress" homogenizer--capacity 90 gallons per hour. Davis-Watkins Co.
3. Two section surface tubular cooler, each section measuring 50 by 18 inches. Cooled by cold brine. Creamery Package Co.
4. Forty quart freezer—"Perfection Brine Freezer." J. G. Cherry Co.
5. "De Raef"—Ice Cream Weight Standardizer, made by N. A. Kennedy Supply Co.
6. Scott's viscosimeter.
7. MacMichael viscosimeter.

8. Type K outfit of Leeds and Northup Co., with Bailey's hydrogen electrode.

9. "Mojonnier Tester" for the determination of total solids and butterfat. Mojonnier Brothers.

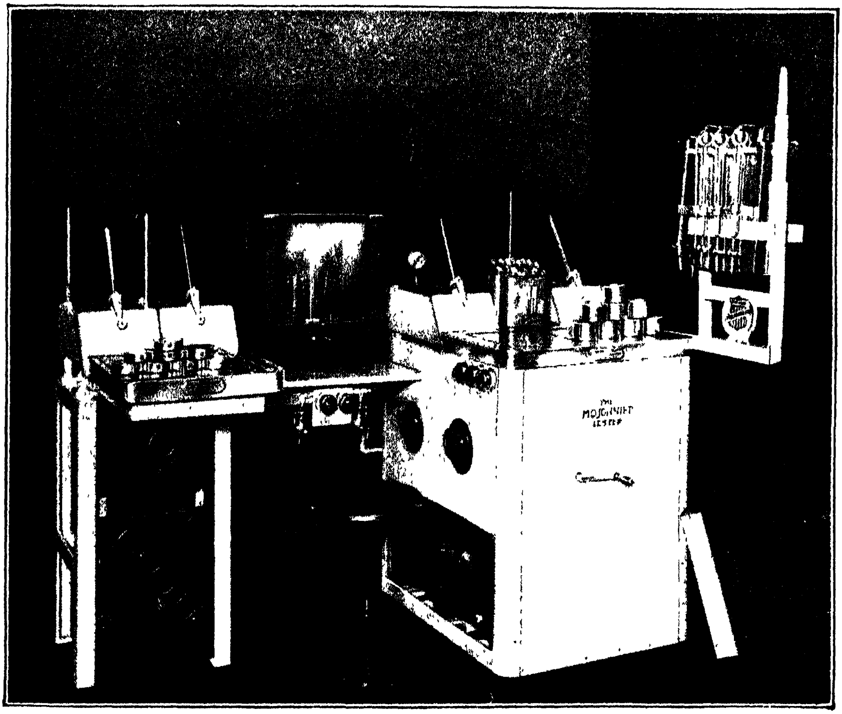

FIG. 1. MOJONNIER TESTER USED FOR THE DETERMINATION OF TOTAL SOLIDS AND BUTTERFAT IN THE EXPERIMENTAL ICE CREAM MIXES

DESCRIPTION OF METHODS

Procedure I: Preparation of ice cream mix. The cream was standardized to the desired butterfat content by addition of pasteurized sweet skim milk and sometimes salted butter was used to provide the additional requirement of butterfat. The milk-solids-not-fat were derived from powdered skim milk (Merrell-Soule) dissolved in the sweet skim milk. The standardized cream was heated to about 140°F. when the dry powdered gelatin (high grade) thoroughly mixed with the granulated sugar was added. The entire mix was then pasteurized at 145°F. held for thirty minutes and afterwards homogenized at a pressure of 2000 to 2500 pounds per square inch, followed by cooling to about 50°F.

In the case of a stock batch only 85 per cent of the mix was pasteurized and homogenized while the 15 per cent usually was equivalent to sweet skim milk which was added later as desired in the experiment under consideration.

The aging of the ice cream mix was taking place in 10-gallon cans at a temperature of 40° to 45°F.

Procedure II: Determination of titratable acidity. The sample of ice cream mix was kept in a water bath until a temperature of 20°C. was reached. 18 grams of the sample was weighed out into a porcelain dish and diluted with 50 cc. of distilled water. This preparation was thoroughly mixed before titration. The titratable acidity of the mix was determined by the required amount of N/10 NaOH using 5 drops of phenolphthalein as an indicator. The acidity was expressed in cubic centimeters of N/10 NaOH required to neutralize 18 grams of ice cream mix. (This procedure enables one to estimate readily the percentage of titratable acidity by dividing the number of cubic centimeters of N/10 NaOH by 20.)

Procedure III: Determination of pH value. The H-ion concentration was determined electro-metrically on Leeds and Northup Type K potentiometer using Bailey's electrode, saturated KCl calomel cell, and saturated KCl in connecting vessel. The hydrogen electrode was rinsed with some of the sample of the ice cream mix, then filled and saturated with hydrogen gas from a tank containing hydrogen gas manufactured by the Kansas City Oxygen Gas Company. The hydrogen electrode with content was shaken vigorously for two and a half minutes and readings taken on the potentiometer and the voltage converted into pH according to Schmidt-Hoagland tables(6).

Procedure IV: Estimation of buffer action. The sample of ice cream was tested for its pH value then 2 cc. of N/10 NaOH was added to 25 cc. of the original sample mixing it thoroughly with the alkali and its pH value determined. The same procedure was carried out with all the samples of the same mix at different aging intervals.

Procedure V: The determination of viscosity by the use of Scott's viscosimeter. The sample of the ice cream mix was tampered to 20°C. thoroughly mixed and 100 cc. of it was placed in the viscosimeter. Readings were taken at 20°C. The number of cubic centimeters of mix delivered into a 50 cc. graduated glass cylinder in 25 seconds was used as the "viscosity index" for comparing results obtained from the various samples under consideration.

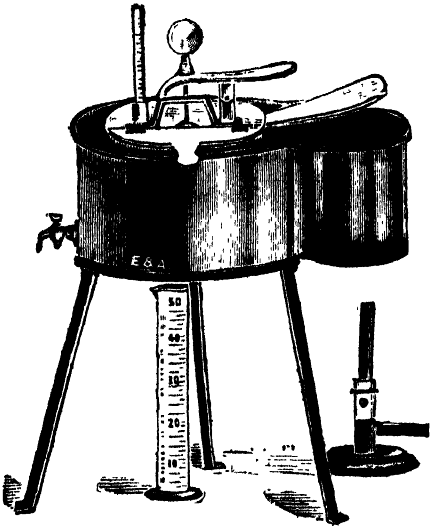

Fig. 2. Scott's Viscosimeter Served as a Means of Indicating the Comparative Viscosities of the Ice Cream Mixes under Experimentation

Procedure VI: Determination of viscosity by MacMichael's method. MacMichael's viscosimeter was used having the cylindrical bob attached to wire No. 30. The sample of ice cream was tempered to 20°C., and delivered into the standard diameter cup until it reached the fourth mark on the bob. The turn table was adjusted to make 20 revolutions in about sixty-two seconds. Readings were taken when the pointer was at its slightest deflection and interpreted in degree of M.

Procedure VII: Determination of butterfat in ice cream mix. The Roese-Gottlieb fat method was used with modifications as required by Mojonnier. The Mojonnier tester was used in this work. The sample was thoroughly mixed and tempered to 20°C. About five grams of the sample was weighed out by means of weighing pipettes and delivered into the extraction flasks.

For the first extraction, 6 cc. of distilled water, 1.5 cc. of NH_4OH, 10 cc. of alcohol and 25 cc. each of ethyl and petroleum ethers were used. After adding water the sample was shaken vigorously and again after adding the ammonium hydroxide, and one-half minute each after adding the alcohol and the two ethers.

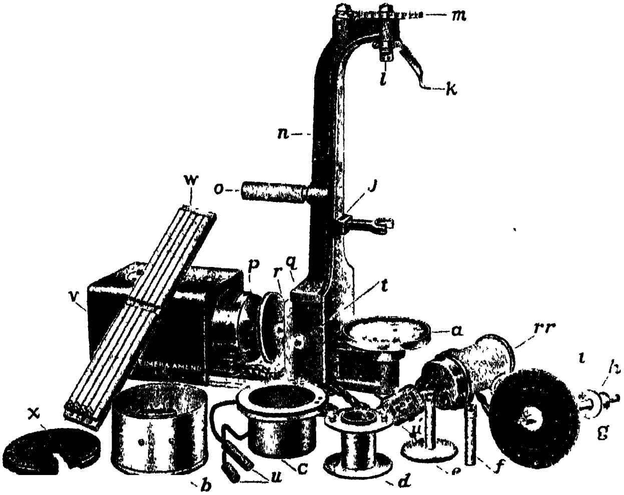

Fig. 3. MacMichael Viscosimeter Used for Measuring the Viscosity of Ice Cream Mixes during Aging

The extraction flasks with their content were placed in the centrifuge and whirled for one minute. The ether extract was then decanted into aluminum dishes of constant weight.

For the second extraction 5 cc. of alcohol, 25 cc. each of ethyl and petroleum ethers were added and the content was shaken for twenty seconds after the addition of each reagent. The centrifuging lasted for thirty seconds. The ether extract was again decanted into the same aluminum dish containing the first extraction. After evaporating off the ether, the dish with the fat was heated in the vacuum oven at 135°C. for five minutes with about 22 inches of vacuum, then placed in the cooling desiccator at room temperature for seven minutes. The percentage of butterfat was calculated from duplicate determinations.

Procedure VIII: Determination of total solids of ice cream mixes. The Mojonnier tester was employed in this work. Duplicate samples, about 1 gram each, were weighed out into the "solids dishes" of the known constant weight. About 1 cc. of distilled water was added to the ice cream mix in the dish mixing and distributing the content evenly on the bottom of the dish and placed upon the solids hot plate. After evaporation the dish was transferred to the solids oven and dried in the oven under 22 inches vacuum for ten minutes. Then the solids dish was transferred to the cooling desiccator for five minutes.

Experiment I. On September 27, 1922, at 4 p.m. the following procedure was carried out in preparing an ice cream mix.

Five pounds of powdered skim milk were dissolved in 10 gallons of sweet skim milk at a temperature between 85° to 95°F. 139 pounds of sweet cream testing 35 per cent butterfat were placed in a pasteurized vat equipped with a horizontally rotating coil. The required amount of 190 pounds of sweet skim milk was added including the 10 gallons of skim milk containing the dissolved 5 pounds of powdered skim milk. When the temperature of the vat content reached 100°F. 8 pounds of salted butter was placed into the vat and shortly after the melting and thorough incorporation of the butterfat 56 pounds of sugar and 2 pounds of gelatin mixed were added to complete the mix requirements. The pasteurization took place at 145°F. for thirty minutes. It was run through a homogenizer at a pressure between 2000 and 2500 pounds per square inch and cooled to about 45°F. The homogenized ice cream mix was placed in sterilized 10-gallon cans set in the "aging" room where it was kept at a temperature below 40°F.

On September 28, 1922, at 10 a.m. a representative sample of the mix under consideration was taken and tested for its butterfat content and total solids using the Mojonnier outfit. It tested 13.75 per cent butterfat and 36.7 per cent total solids.

In order to raise the titratable acidity of the mix more rapidly the following preliminary test was made: 9.5 pounds of the mix were placed into each of four "shot-gun" cans numbered 1, 2, 3 and 4.

Then 0.5 pound of "lactone starter"[3] testing 16.7 cc. $N/10$ NaOH or 0.835 per cent lactic acid was added to each of the cans numbered 1, 2, and 3 and 0.5 pounds of pasteurized whole milk was added to can 4 which was used as a check in this experiment. Dairy thermometers were placed in each of the prepared mixes in the "shot guns" and held at different temperatures: can 1 was kept at room temperature, between 60 to 75°F., can 2 and check, can 4 at the temperature of the aging room, 40 to 45°F., can 3 was held at a temperature of 50°F.

The results obtained are given below.

DATE	NUMBER OF CAN	TIME	TEMPERATURE	ACIDITY IN C.C. $N/10$ NaOH	ACIDITY IN PER CENT OF LACTIC ACID
			°F.		
September 28	1	10 a.m.	51	3.4	0.17
September 28	1	3 p.m.	60	3.5	0.175
September 29	1	11 a.m.	75	15.4	0.77
September 28	2	10 a.m.	51	3.4	0.17
September 28	2	3 p.m.	42	3.3	0.165
September 29	2	11 a.m.	44	3.3	0.165
September 28	3	10 a.m.	51	3.4	0.17
September 28	3	3 p.m.	50	3.3	0.165
September 29	3	11 a.m.	50	5.0	0.25
September 28	4	10 a.m.	51	2.6	0.13
September 28	4	3 p.m.	42	2.5	0.125
September 29	4	11 a.m.	44	2.5	0.125

On September 29, 1922, at 3 p. m. the above samples of acidified mix were combined with sufficient of the unacidified mix to make up 45 pounds of ice cream mix the acidity of which was 5.9 cc. $N/10$ NaOH or 0.295 per cent lactic acid. It was frozen in a 25-quart Cherry freezer and with the addition of 4 ounces of caramel made into ice cream.

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[3] Lactone starter is prepared of whole milk inoculated with Ericsson's Butter Culture.

TABLE 1

DATE	NUMBER OF BATCH	NUMBER OF EXPERIMENT	AGING	AMOUNT FROZEN	WEIGHT OF GALLON OF MIX	TEMPERATURE OF MIX	VISCOSITY INDEX	ACIDITY REQUIRE N/10 NaOH	TEMPERATURE OF BRINE	BRINE ON	DE RAEF READING	BRINE OFF	DE RAEF READING	BRINE ON	DE RAEF READING	OVERRUN	REMARKS
			hrs.	*lbs.*	*lbs.*	*°F.*		*cc.*	*°F.*	*min.*	*lbs. per gal.*	*min*	*lbs. per gal.*	*min*	*lbs. per gal.*	*per cent*	
September 29	2a	1	43	45	8.85	44		2.4	2.0	12	5.5	7	4.85			82	
September 29	2b	1	43	45	8.85	44		5.9	2.0	12	5.6	8	4.75			86	
October 18	3a	2	72	45	9.0	41		2.6	3.0	10.5	4.85	7.5	4.60			95	Aged with starter or twenty-four hours
October 18	3b	2	72	45	9.0	41		7.5	4.0	10.5	4.75	7.0	4	3	4.5	100	
October 26	4a	3	19	42	8.85	48	6	2.3	3.0	10	5.50	8	4.50			98	
October 26	4b	3	19	42	8.85	48	4	7.0	3.0	10	5.0	8	4.25			110	
October 30	5a	4	3	44.5	8.70	60	12	2.4	5.0	10	5.85	9	4.85			76	
October 30	5b	4	3	44.5	8.70	57	5	4.7	5.0	9	5.75	9	4.75			84	
November 6	6a	5	3	44	8.70	57	11.5	2.5	7.5	10	5.60	7	4.35	2	4.35	100	Exceptionally smooth texture
November 6	6b	5	3	44	8.70	57	7	4.8	7.5	10	5.50	8	4.35	2	4.35	100	Exceptionally smooth texture
November 13	7a	6	2	44.5	8.70	59	11.5	2.3	7.0	10	5.70	10	4.50			94	
November 13	7b	6	2	44	8.70	56	4.5	4.9	7.0	10	5.35	10	4.50			94	
November 15	8a	7	48	42.5	8.70	58	4.0	2.4	4.0	8	5.50	10	4.35			100	
November 15	8b	7	48	42.5	8.70	59	4.0	2.4	4.0	9	5.60	12	4.35			100	
November 15	9a	7	48	41.0	8.70	60	5.5	2.5	4.0	9	5.70	12	4.35			100	Aged for twenty-four hours with additional skim milk
November 15	9b	7	48	40.5	8.70	59	2.3	5.35	4.0	9	5.70	14	4.35			100	Aged for twenty-four hours with starter
December 8	10a	8	72	41.0	8.35	38	6.0	2.5	2.0	7	5.50	11	4.25			97.1	
	10b	8	72	41.0	8.25	40	5.2	2.4	3.0	8	5.60	15	4.12			100	Aged for twenty-four hours with additional skim milk
	10c	8	72	41.0	8.50	40	2.3	5.3	4.0	8	5.50	16	4.25			100	Aged for twenty-four hours with additional starter

The lactone flavor was somewhat noticeable shortly after drawing the ice cream from the freezer but on hardening the blending of the caramel and lactone flavor became more agreeable to the palate.

For data during freezing see table 1 under batches 2a and 2b.

Experiment II. On October 15, 1922, at 11 a.m. a 400-pound mix of the following composition was pasteurized at 145°F. for thirty minutes and homogenized at 2000 to 2500 pounds pressure per square inch:

	pounds
Cream testing 17.5 per cent butterfat	329
Powdered skim milk	5
Butter (salted)	8
Sugar (granulated)	56
Gelatin	2

Total of 400 pounds testing 14.4 per cent butterfat and 36.7 per cent total solids

This mix was held in 10-gallon cans at 40° to 45°F. until October 17, 11 a.m. when the following modification was made. To 59 pounds of the original mix 9 pounds of raw cream, testing 43.5 per cent butterfat, was added; also, 23 pounds of whole milk starter and 4.5 pounds of sugar. The acidity of the starter was 15.8 cc. N/10 NaOH or 0.79 per cent lactic acid and the original mix had an acidity of 2.65 cc. N/10 NaOH or 0.13 per cent lactic acid. On October 18, 1922, at 9 a.m. the freezing of batches 3a and 3b took place. (See table 1.) The acidity of the modified mix was 7.5 cc. N/10 NaOH. There was less viscosity, at sight, in batch 3b and a tendency to swell was more noticeable than in case of batch 3a.

This time 4 ounces of vanilla flavoring was used in each batch. The lactic acid flavor persisted even during the hardening process.

Experiment III. On October 25, 1922, at 4 p. m. a stock batch was prepared so as to fulfill the desired composition when 15 per cent skim milk starter[4] or sweet skim milk is added to it. The composition of the stock batch follows:

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[4] Skim milk starter was prepared from sweet skim milk inoculated with Ericsson's Butter Culture.

60.5 pounds of cream testing 45 per cent butterfat
78.5 pounds of skim milk
2.25 pounds of powdered skim milk
28.0 pounds of granulated sugar
1.0 pounds of gelatin

170.25 pounds of stock batch testing 16 per cent butterfat and 40.11 per cent total solids

The stock batch was pasteurized at 145°F. for thirty minutes; homogenized at 2000 to 2500 pounds pressure per square inch and cooled at 52°F.

To 73 pounds of the homogenized stock batch 12 pounds of skim milk starter was added making a total of 85 pounds of mix to represent experimental batch 4b: to another 73 pounds of the stock batch 12 pounds of raw sweet skim milk was added making 85 pounds of mix used as batch 4a. Both batches, 4a and 4b were aged for nineteen hours.

From a study of table 1 it is apparent that the 0.35 per cent lactic acid in batch 4b helped to increase viscosity of the mix before and during aging and later during freezing facilitated in obtaining "overrun."

Experimental batch 4a tested 12.8 per cent butterfat 14 per cent sugar and 35.75 per cent total solids. Batch 4b tested 12.8 per cent butterfat, 4 per cent sugar and 36.12 per cent total solids.

Experiment IV. On October 30, 1922, at 11 a.m. a stock batch of the following composition was prepared:

60.0 pounds of sweet cream testing 47.5 per cent butterfat
80.0 pounds of sweet skim milk
2.25 pounds of powdered skim milk
1.0 pounds of gelatin
28.0 pounds of granulated sugar

171.25 pounds of stock batch testing 16.5 per cent butterfat and 40.5 per cent total solids

The process of pasteurization, homogenization and modification of the mixes were similar to those performed in experiment III with the exception that batches 5a and 5b were aged for three hours instead of nineteen hours as in the preceding experiment.

Examining data in table 1, we find that the addition of skim milk starter to form batch 5b raised the viscosity as well as the acidity of the mix. The results obtained during freezing indicate that a slight gain in time is made to reach a certain point of overrun when the brine is on, but the total time of freezing is about the same for batch 5b as for batch 5a. Another point worth noticing is that no gain in overrun is obtained when the increase of viscosity is due to a rise in acidity and not aging.

Experiment V. On November 6, 1922, at 11 a.m. the following stock batch was prepared:

138.0	pounds of cream testing 41 per cent butterfat
142.0	pounds of sweet skim milk
4.5	pounds of powdered skim milk
56.0	pounds of granulated sugar
2.0	pounds of gelatin
342.5	pounds of stock batch testing 16.5 per cent butterfat and 40.2 per cent total solids

To 73 pounds of stock batch 12 pounds of pasteurized sweet skim milk was added making up 85 pounds of experimental batch 6a and to another 73 pounds of the stock batch 12 pounds of skim milk starter was added to make 85 pounds of batch 6b.

Composition of batches 6a and 6b

	AMOUNT	BUTTERFAT	SUGAR	MILK-SOLIDS-NOT-FAT	GELATIN	TOTAL SOLIDS
	pounds	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Batch 6a	85	14.04	14	8.26	0.5	36.80
Batch 6b	85	14.35	14	7.92	0.5	36.77

The handling of the stock batch and its modification for the preparation of batches 6a and 6b were similar to those described in experiment IV.

A study of table 1 shows that during the process of freezing batches 6a and 6b the results were identical although there was a difference in the viscosity and acidity of the batches used. Furthermore, there appears to be no necessity for prolonged aging of an ice cream mix to insure a 100 per cent swell provided proper care is taken during pasteurization and homogenization of the ice cream mix properly composed.

Experiment VI. On November 13, 1922, at 11 a.m. a stock batch was prepared consisting of the following ingredients:

123.5 pounds of cream testing 45.5 per cent butterfat
156.0 pounds of sweet skim milk
5.0 pounds of powdered skim milk
56.0 pounds of granulated sugar
2.0 pounds of gelatin

342.5 pounds of stock batch testing 16.5 per cent butterfat and 40.2 per cent total solids

This ice cream mix was pasteurized at 145°F. for thirty minutes, homogenized at 2000 to 2500 pounds pressure per square inch and cooled to 54°F. Immediately after cooling the homogenized mix 12 pounds of pasteurized sweet skim milk was added to 73 pounds of stock batch forming 85 pounds of batch 7a and to another 73 pounds of stock batch 12 pounds of skim milk starter was added making up 85 pounds of batch 7b.

Composition of batches 7a and 7b

	AMOUNT	BUTTERFAT	SUGAR	MILK-SOLIDS NOT-FAT	GELATIN	TOTAL SOLIDS
	pounds	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Batch 7a...........	85	14.28	14	7.72	0.5	36.5
Batch 7b...........	85	14.28	14	7.72	0.5	36.5

These two batches were frozen at 2 p.m. November 13, 1922. From a study of table 1 it is noticed that the addition of skim milk starter raised the viscosity as well as the acidity of batch 7b. There appeared to be, however, no significant difference in results obtained during the freezing process save a slight gain in time in favor of batch 7b in reaching a greater overrun in the same number of minutes while the brine was on.

Experiment VII. On November 15, 1922, at 10 a.m. experimental batches 8a and 8b were prepared by adding 12 pounds of pasteurized sweet skim milk to 73 pounds of stock batch which has been used in the previous experiment. At the time this addition was made the stock batch had been aged for forty-eight hours.

On November 14, 1922, at 10 a.m. batch 9a was prepared by adding 6 pounds of pasteurized sweet skim milk to 36.5 pounds of stock batch made on November 13 and which had been aged for twenty-four hours.

Similarly batch 9b was prepared except that 6 pounds of skim milk starter was taking the place of the pasteurized sweet skim milk. Both batches, 9a and 9b were aged for twenty-four hours.

From a study of table 1 it is apparent that the difference in viscosity of the same ice cream mix does not influence the results obtained during freezing.

Experiment VIII. On December 5, 1922, at 11 a.m. the following stock batch was prepared:

95.0 pounds of sweet cream testing 44.3 per cent butterfat
113.0 pounds of sweet pasteurized skim milk
3.5 pounds of powdered skim milk
42.0 pounds of granulated sugar
1.5 pounds of gelatin

255.0 pounds of stock batch testing 16.4 per cent butterfat and 43.8 per cent total solids

Experimental batch 10a was prepared by adding 12 pounds of pasteurized sweet skim milk to 73 pounds of the above prepared stock batch and allowed to age at 40°F.

On December 7, 1922, the following experimental batches were prepared: to 73 pounds of stock batch obtained on December 5 and aged at 40 to 45°F. for forty-eight hours 12 pounds of pasteurized sweet skim milk was added thoroughly mixed and obtaining experimental batch 10b which was then aged for twenty-four hours.

Experimental batch 10c was prepared in the same way as 10b except that 12 pounds of skim milk starter was used instead of pasteurized sweet skim milk.

On December 8, 1922, at 3 p.m. the freezing of 10a, 10b and 10c took place. Examining table 1 it is apparent that in spite of different viscosities of the mixes there were no differences in the results obtained during freezing. This substantiates the results obtained in experiment VII. It proves, further, that high viscosity obtained by increasing the acidity of the ice cream mix does not influence the yield to any noticeable extent as compared with a low viscosity of the same mix obtained through aging.

Experiment IX To determine the H-ion concentration of some of the experimental batches the Bailey electrode was found to be satisfactory in this work. Samples of experimental batches were tested for viscosity and H-ion concentration simultaneously. The following results were obtained:

DATE	TIME	NUMBER OF BATCH	VISCOSITY	pH VALUE	REMARKS
			°*M*.		
December 5.......	2 p.m.	10a	17.5	6.49	Normal mix
December 6.......	8 a.m.	10a	23.5	6.49	Normal mix
December 6.......	4 p.m.	10a	30.0	6.49	Normal mix
December 7.......	8 a.m.	10a	23.5	6.48	Normal mix
December 8.......	9 a.m.	10b	46.0	6.46	Modified after aging for forty-eight hours
December 8.......	9 a.m.	10c	60 0	5.76	Content 15 per cent starter

Experiment X. On December 11, 1922, 20 pounds of mix IIa was prepared in a "shot-gun" can by placing it in a water bath of 145°F. and by frequent agitation of the mix in the can pasteurization took place at 145°F. for thirty minutes, then, immediately cooled to about 50°F. and placed in the aging room at 42°F. The composition of this mix was 14 per cent butterfat, 14 per cent sugar, 1.2 per cent powdered skim milk and 0.5 per cent gelatin, and with a total solids of 35.9 per cent. Samples of this batch were tested for viscosity, pH value, amd buffer action.

The following results were obtained:

DATE	TIME	NUMBER OF BATCH	VISCOSITY	pH VALUE	BUFFER ACTION IN pH
			°*M*.		
December 11..............	12 n.	11a	5.5	6.46	7.15
December 11..............	3 p.m.	11a	9.5	6.46	7.16
December 12..............	9 a.m.	11a	194.0	6.46	7.16

CONCLUSIONS

A total of 839 pounds of ice cream mix were used for work in connection with experiments on the rôle of acidity in the manufacturing of ice cream.

The titratable acidity of the ice cream mix was raised by the addition of "starter" made from Ericsson's butter culture.

1. The addition of starter to the homogenized mix tends to increase the viscosity before and during aging.
2. Comparing the effects of a viscous mix produced by raising its titratable acidity and those due to aging it was found to give different results during the freezing process.
3. Comparing results obtained from a mix of high viscosity due to high acidity and a mix with a lower viscosity due to aging but of low acidity no decided differences were noticed during the freezing process.
4. There appears to be no change in the pH value of a normally handled ice cream mix during aging for twenty-four to forty-eight hours.
5. The buffer action is apparently undisturbed during the aging of an ice cream mix which has been prepared in a normal way.
6. Since the introduction of acidity imparts objectionable flavor in many ice creams and does not noticeably influence the physical make-up of the ice cream mix during aging and freezing it would not be good practice to use dairy products of high acidity in ice cream making, so far as practicability is concerned.

I wish to express my thanks to Dr. M. J. Blish, Head of the Agricultural Chemistry Department, for advice in connection with the H-ion concentration work, and to Prof. John A. Luithly, Head of the Dairy Manufacturing Department, for hearty cooperation and personal interest taken in these experiments.

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THE PROBLEM OF TRANSPORTING MILK IN HOT CONDITION

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Since glass-lined tanks mounted on railroad cars and automobile trucks have come into use for the transportation of milk, the question has again been raised as to whether milk could not be heated and kept hot during transportation and bacterial growth checked by heat rather than by refrigeration.

This is a logical question for an engineer to ask, for he is not expected to have any knowledge of the thermophilic types of bacteria. (The term thermophilic is used in its correct sense, meaning bacteria which grow at high temperature.) But the bacteriologist will at once think of these bacteria and will question the practicability of shipping the milk hot. However, even though we admit there are thermophiles in milk, we can not tell in advance what their action will be or how quickly they will act, without actual data on the subject. For this reason we wish briefly to report the results of a few experiments.

As early as 1867 Muller (4) while studying the influence of temperature on milk souring found that milk held at 50°C. (122°F.) became sour and appeared greenish-yellow, the same as at 35°C. (98°F.). He came to the conclusion, however, that at 50°C. (122°F.) the souring appeared to be due to a different kind of fermentation from that at lower temperature, and that it should be investigated. Leichmann (3) in 1894 found that milk coagulated after twelve to fifteen hours when held at 50°C. (122°F.) and that a fine coagulum appeared. He pointed out that this fermentation was not due to the ordinary milk-souring organism.

These fermentations were undoubtedly due to thermophiles, which under favorable conditions may develop and play an important rôle in the changes that take place in the milk and dairy products. Jensen (2) has recognized this fact and recommended that skimmed milk be cooled after pasteurization at the creamery, instead of being returned hot to the producer, because changes were produced in it by the growth of thermophiles. Recent studies by the authors have shown how Lactobacillus thermophilus grows in the milk at high temperatures and how it is related to pin-point colonies and high counts in pasteurized milk.

This knowledge of the ability of bacteria to grow in milk at high temperatures clearly indicates that difficulties may be expected in substituting heat for cold in the transportation of milk.

The idea of keeping milk hot during shipment is by no means a new one. Bernstein (5) in 1893 advanced the idea that instead of refrigerating milk it could be heated to about 70°C. (158°F.) and kept at that temperature during transportation. His general plan, which may be of interest, was as follows:

At suitable stations along the railroad he planned collecting stations. There milk was to be tested and heated to the desired temperature for transportation.

For transport, differently constructed railroad cars were to be used according to the distance of shipment.

For long distances, tank cars were to be used, consisting of long cylindrical tanks surrounded by a hot-water jacket. The temperature was to be kept constant by a hot-air oven and the milk kept in motion by an electric motor which was to receive its current from a storage battery.

For short distances, heating could be omitted because of the large volume of heated milk, surrounded by insulation, which would change temperature only slowly.

Upon arrival at its destination, the milk was to be cooled rapidly to a very low temperature and then supplied directly to distributors in closed vessels.

Bernstein made one experimental run from Hamburg to Berlin, a ten-hour trip, with a small experimental apparatus, and says the milk was found to be excellent upon its arrival. Probably difficulties were encountered, as one might expect, for the method has not been used commercially so far as is known.

It is true, however, that the heating of milk in an evaporated form has been resorted to in some instances in this country for short shipments when refrigeration has not been easily available.

EXPERIMENTAL RESULTS

The authors have made a number of experiments in which fresh milk was heated and held at various temperatures and examined at frequent intervals up to twenty-four hours.

One liter of milk was used in each experiment which was flashed to the desired temperature, then placed in a sterilized glass museum jar of 1.5 liters capacity. This jar was covered with a heavy brass top which fitted on to the ground-glass top of the jar so that evaporation was practically eliminated. A propeller shaft extended through the brass top into the milk and this propeller was rotated at a speed just sufficient to prevent the melted butter fat from rising to the surface. The jar of milk was held in a water bath and the temperature kept constant at the desired point.

In a preliminary experiment with milk held at 60°C. (140°F.) it was found that after twenty-four hours the acidity had increased and the milk was coagulated to a very fine curd. This indicated that thermophilic bacteria were present, and therefore in most of the experiments bacteria counts were made at two temperatures.

It will be apparent from table 1 that milk can not be held at any temperature from 50°C. (122°F.) to 60°C. (140°F.) for twenty-four hours without undergoing changes produced by bacteria growth. When held at 50°C. (122°F.) a rennet curd is likely to develop with some acidity as well. When the milk was not coagulated and appeared normal, it had a strong bitter taste, clearly indicating proteolysis with peptone formation. At 60°C. (140°F.) the fermentation was more strictly of the acid type. Even though the acidity did not develop to a point which might be expected to be required to coagulate milk, coagulation usually occurred after twenty-four hours holding. However, it must not be forgotten in this connection that the effect of acid is increased by the long heating at high temperatures.

TABLE 1

Bacteria counts of milk held at different temperatures for different periods

TEST NUMBER	MILK HOLDING TEMPERATURE	RAW MILK		PLATE INCUBATION TEMPERATURE	SECOND EXAMINATION		THIRD EXAMINATION, AFTER TWENTY-FOUR HOURS		
		Bacteria per cubic centimeter	Per cent acidity		Hours held	Bacteria per cubic centimeter	Bacteria per cubic centimeter	Per cent acidity	Remarks.
1	50°C. (122°F.)	62,000	0.16	30°C.			1,770,000	0 38	Coagulated, (rennet)
2	50°C. (122°F.)							0 24	Not coagulated
3	55°C. (131°F.)	2,700	0 17	30°C.	4	900	24,700	0.34	Not coagulted
4	55°C. (131°F.)								Coagulated
5	60°C. (140°F.)	91,000	0 19	37°C.	6	10	70	0 41	Sour, not coagulated
	60°C. (140°F.)	5–1/100 cc.		55°C.	6	0–1/100 cc.	3,100,000		
6	60°C. (140°F.)	17,700	0.17	30°C.			3,100	0.27	Not coagulated
	60°C. (140°F.)	900		55°C.			5,340,000		
7	60°C. (140°F.)	42,000	0.17	30°C.	8	900	3,400	0.30	Very fine curd
	60°C. (140°F.)	0–1/1000 cc.		55°C.	8	75,000	440,000		
8	60°C. (140°F.)	60,000	0.18	37°C.	6	50		0.27	Coagulated, whey
	60°C. (140°F.)	20		60°C.	6	1,730*			
9	60°C. (140°F.)	25,700	0.17	37°C.	4	70	280,000	0.32	Coagulated, fine curd
	60°C. (140°F.)	420		60°C.	4	90	728,000		

* Also a large number of pinpoint colonies.

Further study of the results reveals the fact that the bacteria count made at 30°C. (86°F.) and 37.7°C. (100°F.) usually showed low numbers after twenty-four hours while the counts made by incubation at 55°C. (131°F.) and 60°C. (140°F.) showed high numbers. This, of course, might be expected, since we are dealing with bacteria which grow at high temperatures.

A study of a few cultures isolated from milk held for twenty-four hours at temperatures ranging from 50°C. (122°F.) to 60°C. (140°F.) showed two general types. One consisted of spore-forming peptonizing and rennet-producing bacteria which developed most rapidly from 40°C. (104°F.) to 50°C. (122°F.). The other type consisted of weak acid-producing bacilli resembling Lactobacillus thermophilus. These organisms grew more rapidly at temperatures from 50°C. (122°F.) to 60°C. (140°F.), which probably explained the difference in the type of fermentation observed in milk held at 50°C. (122°F.) and 60°C. (140°F.).

From these results it is evident that milk can not be held at high temperatures for a period of twenty-four hours without undergoing changes which would make it valueless for commercial purposes. Therefore, for this holding period heat can not replace refrigeration.

It is possible to conceive conditions where the use of heat in place of cold might be practicable for short shipment distances, provided the period of holding is less than twenty-four hours. As an example of such a condition, the collection of milk in tanks on automobile trucks where it can be heated to and held at a desired temperature by hot exhaust gases from the engine may be mentioned. Here the holding period during transportation would only be a few hours. Whether or not such a plan is feasible will depend upon a number of things: First, the growth of thermophilic bacteria during holding periods shorter than twenty-four hours; second, the physical and chemical changes produced, and third, the use which will be made of the milk. We do not have complete data on these points, but that which is available may be of interest.

Referring again to table 1 it will be noted that a number of lots of milk were examined for bacteria after being held from four to eight hours. Apparently the thermophilic bacteria had not developed to any great extent during these holding periods, although in one experiment where milk was held for eight hours at 60°C. (140°F.) the thermophiles increased to 75,000 per cubic centimeter. Milk to be used for manufacturing purposes such as butter making could perhaps be shipped hot if the transportation period did not exceed six hours. In suggesting this possibility we are considering only the bacteria changes. It remains to be determined whether or not the effect of long heating would show an effect on the butter made from it.

We are inclined to believe that the heating of milk during transportation even for short periods is not practical if the milk is to be consumed in the fluid state.

INFLUENCE OF LONG HEATING ON THE CREAM VOLUME

In discussing the feasibility of transporting milk, in a hot condition, which is to be consumed in a fluid state, the question of the effect on the cream volume is of primary importance.

A number of experiments were made to determine this effect and the results are shown in table 2. The milk used was fresh milk, less than five hours old. It was flashed to the desired temperature, then held for the desired time, and agitated during the holding period. For the determination of the percentage of cream volume the method described by Harding (1) was used.

While the experiments were only a few in number they indicate what the probable effect of long heating will be. Heating for six hours at temperatures of 50°C. (122°F.) and 55°C. (131°F.) apparently had no effect on the cream volume. After twenty-four hours at 50°C. (122°F.) the cream volume was not affected in one experiment, although in the other it was reduced nearly 50 per cent.

When milk was held at 60°C. (140°F.) variable results were obtained with short holding periods, and some reduction was observed after three hours heating. No measurements could be obtained after twenty-four hours holding, since the milk was always coagulated. When the milk was heated to 62.8°C.

(145°F.) and held for one hour the cream volume was not changed, although it was reduced after two hours holding.

The effect of long heating on the cream volume causes another complication in the transportation of hot milk which is to be consumed in the fluid state.

TABLE 2

Effect of temperatures and different holding periods on the cream volume

TEST NUMBER	HOLDING TEMPERATURE	FAT IN MILK	CREAM VOLUME IN RAW MILK	CREAM VOLUME IN MILK AFTER DIFFERENT HOLDING PERIODS					
				½ hour	¾ hour	3 hours	4 hours	6 hours	24 hours
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1	50°C. (122°F.)		15.0	15.0				16.0	8.0
2	50°C. (122°F.)	3.5	13.5	12.5				13.5	14.0
3	55°C. (131°F.)		14.0	14.0				14.5	
4	55°C. (131°F.)		12.5	12.5				13.0	
5	60°C. (140°F.)	3.4	14.5		17.5	15.2		12.2	
6	60°C. (140°F.)	4.1	18.5	19.5			17.5	16.5	
8	60°C. (140°F.)	3.2	14.0	14.0				8.5	
8	60°C. (140°F.)	2.8	13.0	13.0		10.0		10 0	
9	62.8°C. (145°F.)		15.5	15.5	15.5* 12.0†	7.0		5.5	

* Held one hour.

† Held two hours.

SUMMARY

It is shown that the growth of thermophilic bacteria complicates the scheme for transporting milk in a hot condition.

Another factor is the effect on the physical condition of the milk.

Milk held at temperatures ranging from 50°C. (122°F.) to 60°C. (140°F.) for a period of twenty-four hours is usually coagulated. The type of fermentation at 50° C. (122°F.) appears to be different from that at 60°C. (140°F.).

The results do not indicate that heat can be used as a substitute for cold during periods of transportation. This is particularly true with milk for direct consumption.

It may be feasible to ship milk in a hot condition under conditions where milk is to be used for the manufacture of butter and where the transportation period is not over a few hours. Further study of this problem is however required.

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THE WIDE DISTRIBUTION OF ROPY MILK ORGANISMS IN CITY MILK SUPPLIES

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The occurrence of the viscid condition in milk, commonly called ropy milk, constitutes one of the most serious causes of complaints with which milk dealers have to contend. Ropy milk is harmless but the viscid, slimy consistency is not familiar to the consumer, and the detection of the condition causes loss of trade. Ropy milk is more common in the raw product but occurs in pasteurized milk and its repression calls for vigilance on the part of the employees of establishments marketing this product.

EARLY OBSERVATIONS

In 1898, the writer began the study of a series of outbreaks of ropy milk, and embodied these observations in two bulletins. The outstanding facts observed were: the relation of Bacterium lactis viscosum (Adametz) to the trouble, the ability of the organism tc grow at unusually low temperatures where acid producing organisms are relatively inactive, the relation of faulty scalding of milk utensils to the continuance of the trouble and the frequent occurrence of the organisms in air and floor dust. The prevalence of the organism in water used for cooling was constantly noted in the milk plants studied.

The distribution of ropy milk organisms was first studied in two establishments at a time when the consumers were complaining of the product. These organisms were found in improperly scalded utensils, in the water of can cooling tanks but not in the milk as it came from the farms. During the investigation of another plant, ropy milk was detected in milk cooled in ice water, although the condition was not recognized by the consumers. Ropy milk organisms were also found in the ice water of the cooling vat, in certain utensils, in floor dust, and in samples of sterile milk exposed to contamination from the air. Infection was likewise found in water as delivered from a hose, but not in water from other sources. The ropy milk organisms were also found in unscalded utensils at the farm.

These early observations dealt with the occurrence of the trouble in small retail establishments provided with much simpler equipment than used at present and at a time long before modern pasteurization was practised.

RECENT WORK

There has come to notice but one piece of work, that by Harding and Prucha (3) concerning ropy milk as occurring in modern milk plants. These writers studied outbreaks of ropy milk in the bottled product of several pasteurizing plants. They showed that the accepted pasteurizing process kills the ropy milk organisms. Nevertheless, the outbreak was repressed only by the exercise of great vigilance due to the numerous opportunities for re-contamination.

The most recent summary of the strictly bacteriological phases of the subject is embodied in a bulletin by Buchanan and Hammer (4) who include an extensive bibliography.

METHODS

In connection with his earlier work on ropy milk the writer developed the method of searching for ropy milk organisms by exposing sterile milk to contamination in various suspected utensils. The method has likewise proven of value in the most recent studies. Ordinary tubes of sterile milk were prepared. When conditions were suitable the milk was poured into the utensil, and immediately as much as possible was recovered. In other cases suspected material was added to the tubes. The infected samples of milk were then held at about 55°F. and examined several days later. This temperature was selected because ropy milk organisms could grow here without much competition from the acid producing organisms. It was also preferable to anything higher because it commonly occurred in the available ice-cooled refrigerator.

After standing a few days, the ropy milk infection may be detected by the viscid condition as revealed by the use of the platinum loop. The layer of cream is a disadvantage in making this test as the physical characteristics of cream mask the lower degrees of viscosity. Skimmed milk has been used in all the recent work. In this material very slight ropiness is revealed by the gossamer-like thread of milk connecting the loop with the surface of the fluid. In case of slight viscosity, a fiber of cotton adhering to the loop may cause erroneous conclusions. In the advanced stages, viscosity is such that threads several feet long may be drawn from the surface of the milk.

Similarly, the use of low temperature incubation enables one to take samples of milk at various stages in its course from the cow to the consumer and locate the first point at which ropy milk infection is imparted.

While the general range of temperature favorable to the development of ropiness in milk is known, lack of suitable apparatus has prevented the determination of the exact optimum temperature for the development of this condition in milk containing a mixed flora.

For the purposes of the work in hand, 60°F. has been assumed to be the favorable temperature and various devices have been employed to secure this. We know that 68°F. the lactic acid organisms overgrow the ropy milk organisms and effort has been made to keep at least 5° below this point. In hot weather, samples have been kept in a refrigerator at about 55°F. and such samples have developed ropiness in a period varying from four to seven days. During the period in the autumn when the temperature of the city water supply was about 60° this water was utilized for securing a constant temperature and results were obtainable in two or three days. In winter, the cooler parts of heated rooms have been employed.

PHASES OF PROBLEMS NOT STUDIED

The present work has not included the isolation of strains of bacteria and their study on various media. The alteration of the physical characteristics of the milk when it became viscid at a temperature of 55° to 60°F. was deemed sufficient for the purposes of the study of the phase of the subject in hand. Thus, the ropy milk to which the writer refers, is that which occurs at the lower temperatures and does not concern those organisms producing viscosity at higher temperatures. The study of strains is an attractive field which has not been entered upon in the present study.

NORMAL DISTRIBUTIONS OF ROPY MILK ORGANISMS

During the past summer, autumn and early winter, opportunity has been afforded to carry out a study of the occurrence of ropy milk organisms in a city milk supply in the absence of an outbreak of ropy milk. The dealer who furnished the facilities for the study carried on an extensive trade in market milk pasteurized in a number of plants. During the period covered by my observations (August 1 to the end of the year) no complaints of ropy milk were received from the consumers. Routine examinations were made weekly by the company's laboratory staff of samples of milk from the various bottling plants. These were kept at a temperature approximately 55°F. and examined with a platinum loop after four days. Under such conditions of time and temperature occasional samples became slightly but distinctly ropy. The conditions were favorable for a study of the occurrence of ropy milk bacteria in the milk supplied these plants under normal conditions as contrasted with a period when ropy milk was causing complaints.

ROPY MILK DELIVERED BY PATRONS

The occurrence of ropy milk organisms in samples of milk from each producer was studied in three plants. Milk was collected in half pint bottles which were fresh from exposure to 200°F. for ten minutes and which had been kept inverted in racks until used. As each can of a patron's milk was dumped, a small portion was collected in a bottle. The resulting sample was a rough composite of the patron's milk, surely containing representation of both morning's and evening's milk. Each bottle was covered with the ordinary bottle cap, upon which the identification number was written.

The samples were stored in bottle cases in the cool room of the plant for four days at a temperature not exceeding 55°F.

The results obtained from a study of the milk of all of the patrons at three shipping stations, showing the proportion of these which were bringing ropy milk germs are shown in table 1.

Thus 13 per cent of samples from 307 patrons held at a low temperature became ropy in four days. It is believed that the temperature employed (40 to 45°F.) was too low for encouraging the development of the maximum number of ropy samples within the time limit employed. With a higher temperature a higher percentage of ropiness doubtless would have been observed.

TABLE 1

Development of ropy milk in patron's samples

PLANT	NUMBER PATRONS	NUMBER ROPY	PER CENT ROPY
1	70	11	15
2	91	14	15
3	146	17	11
Total...........	307	42	13

The results indicate that the delivery to these plants of milk contaminated with ropy milk organisms is a very common occurrence.

ROPY MILK AND THE WILLMAN HOLDER

The frequency of the detection of ropy milk organisms in the raw milk suggested the desirability of studying the pasteurizing and bottling processes in relation to ropy milk. The milk was held at approximately 144° for thirty minutes in a Willman holder.

For purposes of studying the problem in hand, the condition of the milk at various stages of its passage through the plant may be designated as follows: (1) raw, as it enters clarifier; (2) heated, or short exposure in heating coils; (3) held, that is after holding 30 minutes; (4) cooled, sampled when leaving cooler and (5) sampled from bottling machine.

Six different sets of samples representing a like number of days runs in three pasteurizing plants were collected. It is not the purpose here to discuss these tests in detail, but only to present data obtained regarding the presence of ropy milk organisms in the milk at various stages.

The prevalence of ropy milk contamination in samples of raw milk is shown by its detection in 36 out of 40 samples taken during these tests. Examination of 32 samples of the momentarily heated milk showed that 9 samples were ropy and 23 not ropy. This is in accordance with our knowledge of the thermal peath point of the organism as shown by Harding and Prucha. Samples of the milk after holding thirty minutes were taken in 24 instances and none became ropy. This result confirms our belief that pastuerization kills the organism. Of the cooled milk, 35 samples were taken and 6 became ropy. Of 44 samples from the bottling machine 18 became ropy. The results obtained from both cooled and bottled milk indicate re-contamination of the product subsequent to pasteurization. Certain runs were so nearly perfect that it may be assumed that such contamination is preventable.

ROPY MILK CONTAMINATION OF UTENSILS

Search for ropy milk organisms by the use of skimmed milk heretofore described, has been made in several plants. Positive results were obtained with great frequency in samples exposed to contamination in any utensil which has been washed but not scalded. Among such are sanitary piping valves, end caps for piping, coolers and the like. The water remaining in such apparatus after washing is found to carry ropy milk organisms. Among pieces of apparatus less apt to be regularly washed and scalded are sample dippers and can stirrers which give a high percentage of positive results. The milky water standing on the floor of plants is highly contaminated with the organisms. Brushes of all kinds are in the same class as demonstrated by placing a few bristles in skimmed milk. Samples contaminated from water obtained from a steam hose gave positive results in several cases, but no water supply has been definitely proven to be a source of introduction of organisms into a plant.

In one plant a positive result was obtained by adding dust from a window sill to skimmed milk. In the same establishment condensation water from the outside of a pipe conveying cool milk was shown to contain ropy milk organisms. The condensation water collecting on the inside of the lids of vat pasteurizers during cooling, has also been found to be infected with ropy milk organisms. Examination of a series of returned, unwashed milk bottles by means of the skimmed milk test revealed a high percentage of bottles harboring ropy milk organisms.

Ropy milk organisms may be regarded as so common as to constitute an ever present source of a possibly serious outbreak. The routine methods of scalding utensils in well managed plants are ordinarily sufficient to prevent the dreaded recognition by customers within the ordinary time limit available. Constant vigilance on the part of employees is necessary to prevent the ropy milk.

GENERAL DISCUSSION

The occurrence of ropy milk to a degree sufficient to cause complaint by the purchasers, seems to be dependent upon several factors: (1) the presence of the necessary germ; (2) suitable temperature for multiplication; (3) sufficient time for growth to a recognizable degree at the temperature to which the milk is subjected.

The foregoing observations indicate that at least slight contamination occurs with a frequency not heretofore recognized.

The facilities for holding milk at a temperature below 55°F. at the disposal of distributors, induce a temperature sufficiently low to hold the multiplication of the ropy milk organisms below the danger point. Household refrigeration in the summer by means of ice, and in winter by means of outdoor temperature, prevents the appearance of ropiness. Time and temperature conditions in the main, are unfavorable to the occurrence of ropy milk.

These controlling factors may vary at any time and result in the occurrence of ropiness within the period ordinarily elapsing before milk is consumed. In this connection, it may be noted that large dealers observe that complaints of ropy milk are most apt to be made in the spring and autumn. In the spring, there is an interval after out-door refrigeration fails to be effective and before the use of ice begins, while in the autumn, the conditions are reversed. During these two periods the milk at the home is ordinarily held at about 60°F. In consequence of these temperature conditions, ropy milk is more frequently observed by consumers in spring and autumn.

The idea of locating the original source of contamination leading to specific outbreaks of ropy milk pervades the earlier discussions of this subject. This reflects the belief formerly held by all of us, that while ropy milk organisms become widely distributed in utensils, in milk, and in places contaminated by ropy milk, that such distribution was temporary. Knowledge of the wide distribution of the organisms during outbreaks was general and stimulated the application of such measures as general disinfection of stables, milk houses and floors.

The facts now available warrant our regarding ropiness as a common change in milk ordinarily repressed by the maintenance of conditions unfavorable to its prompt development. Just as the development of sour milk organisms at higher temperature are controlled by time and temperature, so the development of ropy milk organisms is ordinarily restricted by the same factors.

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